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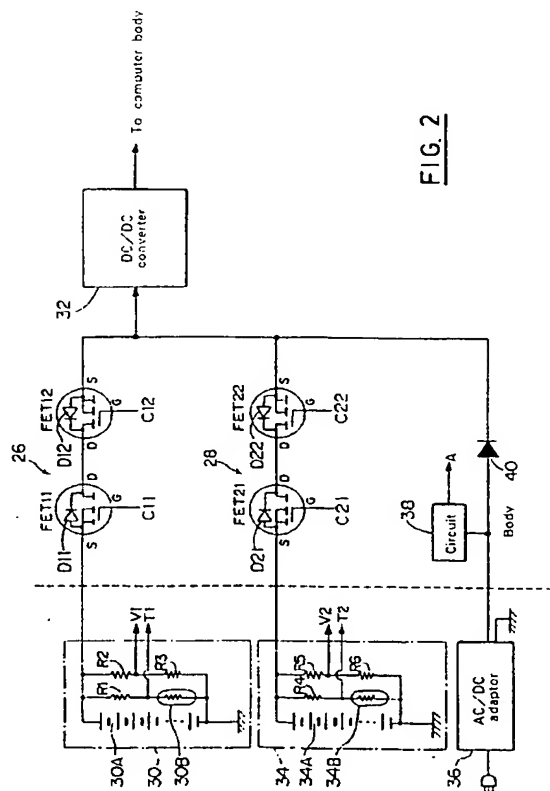
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(54) Battery connecting device for a computer and a method of switching batteries

(57) Disclosed is a battery connecting device and a method for switching batteries that extends the period of period a computer system that is powered by a battery can be operated. The battery connecting device has a plurality of series circuits 26, 28 that are connected to respective battery packs 30, 34 in order to supply power to a computer body. Each of the series circuits is so arranged that the drains of paired field-effect transistors, each of which incorporates a diode that has an anode connected to a source and a cathode connected to a drain, are connected together. To supply power from one of the battery pack 30, FET 11 = FET 12 = on and FET 21 = FET 22 = off, and power is supplied without passing through diodes D11 and D12. Then, the states of the FETs are changed by setting FET 11 = off, FET 22 = on, FET 12 = off, and FET 21 = on, in the named order, so that power is supplied from the other battery pack 34.

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Description

The present invention relates to a battery connecting device for a computer and a method for switching batteries, and more particularly, to a battery connecting device, for a computer, that prevents the power loss that results from the use of a diode and extends a battery operational period, and a method for switching batteries.

In general, a notebook computer incorporates a battery pack (hereafter referred to as a "battery"), and a user employs the battery to operate the computer in those places where an AC power supply is not available. For a notebook computer that has a color liquid crystal display, a fully charged battery will usually operate it for about three hours. The three hours of operation that a fully charged battery may provide, however, are not always sufficient for a user.

A notebook computer in which two batteries are mounted has therefore been proposed.

Fig. 1 is a diagram illustrating a battery connecting device, for a notebook computer in which two batteries are mounted. A first battery 10 is connected via a diode 12, which is positioned in the forward direction, to the input terminal of a DC/DC converter 14 that supplies power to a computer. A second battery 16 is connected to the input terminal of the DC/DC converter 14 via a diode 18, which is also positioned in the forward direction. The first battery 10 and the second battery 16 are OR-connected via the diodes 12 and 18 to the DC/DC converter 14. The diode-OR connection prevents the occurrence, because there is a difference in the potentials of the first and second batteries 10 and 16, of a phenomenon wherein a large current flows between the first and the second batteries 10 and 16 and damages the components that are located between the batteries 10 and 16, a wiring pattern, or the batteries 10 and 16 themselves.

With the above described connection that is employed with two batteries, power from either the first battery 10 or the second battery 16 is supplied to the computer body via the diode 12 or the diode 18 and the DC/DC converter 14.

An AC/DC adaptor 20 that converts an AC input into a DC output is connected between the first battery 10 and the diode 12 via a first charge switch 22, and is further connected between the second battery 16 and the diode 18 via a second charge switch 24, thus providing charging routes in addition to a power supply route along which power is supplied to a computer body via the DC/DC converter 14. Either the first battery 10 or the second battery 16 can be charged along the charging routes, and power can be supplied to a computer body via either the diode 12 or the diode 18 and the DC/DC converter 14.

In a conventional battery connecting device for a computer system, however, the power that is supplied by a battery transits a diode, and the power loss that results from the use of the diode is not negligible. For example, supposing that the capacity of one battery is 30

WH (60 WH for two batteries), a battery voltage is 10.6 V, a diode V_f is 0.6 V, and the consumed power of a computer body is 10 W, a current that flows across the diode is $10/(10.6 - 0.6) = 1$ [A], and the battery operational period is $60 \text{ WH}/(10 \text{ W} + 0.6 \text{ W} \times 1 \text{ A}) = 5.66$ hours.

Further, since charging routes in addition to a power supply route are provided, the structure becomes complicated.

Accordingly, the present invention provides a battery connecting device, for a computer, comprising: a plurality of series circuits including a first series circuit, which includes a first circuit and a second circuit, and with said first circuit having a first switching element, which is connectable separately to a first battery at an input terminal, and a first diode, which has an anode connected to the input terminal of said first switching element and a cathode connected to the output terminal of said first switching element, and with said second circuit having a second switching element, which has an input terminal connected to the output terminal of said first switching element and an output terminal connectable to the computer to supply power thereto, and a second diode, which has a cathode connected to the input terminal of said second switching element and an anode connected to the output terminal of said second switching element; a second series circuit, which includes a third circuit and a fourth circuit, and with said third circuit having a third switching element, which is connectable separately to a second battery at an input terminal, and a third diode, which has an anode connected to the input terminal of said third switching element and a cathode connected to the output terminal of said third switching element, and with said fourth circuit having a fourth switching element, which has an input terminal connected to the output terminal of said third switching element and an output terminal connectable said computer to supply power thereto, and a fourth diode, which has a cathode connected to the input terminal of said fourth switching element and an anode connected to the output terminal of said fourth switching element; and control means for switching said switching elements between ON and OFF states in a predetermined order according to a predetermined conditions.

The invention advantageously reduces the power loss that is occasioned by a diode and that can extend the battery operational period, and a method for switching batteries and further employs a structure that is simplified by the employment of a common route for supplying power and charging.

A further embodiment provides a battery connecting device, for a computer system, comprising a plurality of series circuits, connectable to different batteries to supply power to a computer, each of the series circuits being so arranged that drains of paired field-effect transistors that have a diode are connected.

The present invention also provides a method for switching two batteries, which are connected to paired series circuits of a battery connecting device for a com-

puter system, each of which series circuits includes a first circuit and a second circuit, with the first circuit having a first switching element, which is connectable to a battery at an input terminal, and a first diode, which has an anode connected to the input terminal of the first switching element and a cathode connected to the output terminal of the first switching element, and with the second circuit having a second switching element, which has an input terminal connected to the output terminal of the first switching element and an output terminal connected to a computer body to supply power, and a second diode, which has a cathode connected to the input terminal of the second switching element and an anode connected to the output terminal of the second switching element, comprises steps of: supplying power from one battery to a computer body via the first and the second switching element of one of the series circuits, while supplying power from both of the batteries to the computer body via the first diode; halting the power supply from the battery to the computer body; and supplying power from the other battery to a computer body via the first and the second switching element of the other series circuit.

In an embodiment of the battery connecting device is provided a plurality of series circuits, each of which includes the first circuit, which has the first switching element and the first diode, and the second circuit, which has the second switching element and the second diode, has its input terminal connected to the output terminal of the first switching element and the output terminal connected to the computer body to supply power. Since the first switching element and the first diode, and the second switching element and the second diode are connected in parallel to each other, different batteries are connected to the first switching elements by controlling the ON/OFF states of the individual switching elements, and power can be supplied to the computer body without using the first and second diodes. Therefore, the power loss that results from the use of the diodes does not occur and the operating period for the battery can be extended.

Since power supply is not supplied via the diodes in the battery connecting device cited in claim 1, $60 \text{ WH}/10 \text{ W} = 6$ hours and the operational period can be extended by 0.34 hours (about 20 minutes).

A further embodiment provides a battery connecting device, for a computer, comprising: a plurality of series circuits including a first series circuit, which includes a first circuit and a second circuit, and with said first circuit having a first switching element, which is connectable separably to a first battery at an input terminal, and a first diode, which has an anode connected to the input terminal of said first switching element and a cathode connected to the output terminal of said first switching element, and with said second circuit having a second switching element, which has an input terminal connected to the output terminal of said first switching element and an output terminal connectable to the computer to supply power thereto, and a second diode, which has a cathode connected to the input terminal of said second

switching element and an anode connected to the output terminal of said second switching element; a second series circuit, which includes a third circuit and a fourth circuit, and with said third circuit having a third switching element, which is connectable separably to a second battery at an input terminal, and a third diode, which has an anode connected to the input terminal of said third switching element and a cathode connected to the output terminal of said third switching element, and with said fourth circuit having a fourth switching element, which has an input terminal connected to the output terminal of said third switching element and an output terminal connectable said computer to supply power thereto, and a fourth diode, which has a cathode connected to the input terminal of said fourth switching element and an anode connected to the output terminal of said fourth switching element; and control means for switching said switching elements between ON and OFF states in a predetermined order according to a predetermined conditions.

As described in claim 2, the series circuit in claim 1 can be arranged by connecting the drains of paired field-effect transistors that incorporate diodes that, for example, have their anodes connected to the sources of the transistors and their cathodes connected to the drains.

When a pair of the series circuits are connected respectively to the batteries, power is supplied from one battery to a computer via the first and the second switching element of one of the series circuits, while power is supplied from both of the batteries to the computer body via the first diode, i.e., power is supplied in the diode-OR state. The power supplied by one battery to the computer is halted, and then the power for the computer is supplied by the other battery via the first and the second switching element of the other series circuit. This switching can be performed when the voltage of one battery is reduced to or below a predetermined value.

The switching of the batteries enables power to be continuously supplied to the computer body. In addition, as this switching is performed momentarily, the power that is lost by employing an internal diode is so little that it can be disregarded.

The battery connecting device according to claim 5 comprises the first series circuit, which includes both the first circuit, which has the first switching element and the first diode, and the second circuit, which has the second switching element and the second diode, and the second series circuit, which includes both the third circuit, which has the third switching element, and the third diode, and the fourth circuit, which has the fourth switching element and the fourth diode.

The control means turns on the first and the second switching element, and turns off the third and the fourth switching element in order to supply power from the first battery to the computer body. By doing this, the loss of power that is occasioned by the use of a diode will not occur. Further, when the capacity of the first battery falls to or below a predetermined value, the control means

turns off the first switching element, turns on the fourth switching element, turns off the second switching element, and turns on the third switching element, in the named order, in order to supply power from the second battery to the computer body. Since in this manner power is supplied to the computer body in the diode-OR condition, battery switching can be performed without discontinuing the power supply to the computer body.

When the first battery is fully charged by a converter, which converts AC voltage into DC voltage, and the charging start condition for the second battery is established, the battery connecting device turns off the first switching element, turns on the fourth switching element, turns off the second switching element, and turns on the third switching element, in the named order, to initiate the charging of the second battery. The discharging route (power supply route) can be employed for battery charging. Since the battery connecting device employs the same route both for supplying power and for charging, its structure can be simplified.

When a previous notice for battery removal is detected while power is being supplied from one of the batteries, the battery connecting device controls the ON/OFF state of the first and the second switching element so that two or more batteries supply power to the computer body via the first diode. Therefore, when the previous notice for the battery removal is detected, the battery connecting device is in the diode-OR state and this prevents the power supply from being halted when the battery is removed.

Embodiments of the present invention will now be described in detail with reference to the accompanying drawings in which:

Fig. 1 is a circuit diagram illustrating a conventional battery connecting device for a computer system.

Fig. 2 is a circuit diagram illustrating a conventional battery connecting device for a computer system according to one embodiment of the present invention.

Fig. 3 is a block diagram illustrating a controller that controls the ON/OFF state of an FET in Fig. 2.

Fig. 4 is a flowchart showing the charging and discharging routine for this embodiment.

Fig. 5 is a detailed flowchart for the procedure at step 100 in Fig. 4.

Fig. 6 is a detailed flowchart for the procedure at step 116 in Fig. 5.

Fig. 7 is a detailed flowchart for the procedure at step 122 in Fig. 5.

Fig. 8 is a specific diagram showing how power is supplied from a first battery.

Fig. 9 is a specific diagram showing how power is supplied via an internal diode D11.

Fig. 10 is a specific diagram showing a diode-OR state.

Fig. 11 is a specific diagram showing how power is supplied via an internal diode D21.

Fig. 12 is a specific diagram showing how power is supplied from a second battery.

Fig. 13 is a detailed flowchart for the procedure at step 200 in Fig. 5.

Fig. 14 is a detailed flowchart for the procedure at step 214 in Fig. 13.

Fig. 15 is a detailed flowchart for the procedure at step 218 in Fig. 13.

Fig. 16 is a specific diagram showing how power is supplied from the first battery.

Fig. 17 is a specific diagram showing how an AC/DC converter is connected to the circuit in Fig. 16.

Fig. 18 is a specific diagram showing that an FET 11 is turned off in the circuit shown in Fig. 17.

Fig. 19 is a specific diagram showing that an FET 22 is turned on in the circuit shown in Fig. 18.

Fig. 20 is a specific diagram showing that an FET 12 is turned off in the circuit shown in Fig. 19.

Fig. 21 is a specific diagram showing that an FET 21 is turned off in the circuit shown in Fig. 20.

Fig. 22 is a detailed flowchart for the procedure at step 300 in Fig. 5.

As shown in Fig. 2, a battery connecting device for a computer system in this embodiment comprises a first series circuit 26 and a second series circuit 28. The first series circuit 26 includes field-effect transistors (each of which will hereafter be referred to as an "FET") 11 and 12 that have their drains D connected together. A power MOSFET can be used instead of an FET. The second series circuit 28, as well as the first series circuit 26, includes FETs 21 and 22 that have their drains D connected together.

The FETs 11, 12, 21, and 22 incorporate internal diodes D11, D12, D21, D22, respectively, that have their cathodes connected to the respective drains D and their anodes connected to the respective sources S.

A battery pack (battery) storage unit, which employs as a cover a keyboard that is freely opened and closed, may be provided in a notebook computer body for this embodiment. The source S of the FET 11 is connectable to a first battery pack 30, which is arranged so as to be removable from the battery pack storage unit within the computer. The source S of the FET 12 is connected to the input terminal of a DC/DC converter 32, which supplies power to the computer body. A keyboard switch for detecting the open/closed state of the keyboard is also provided in the computer body. The source S of the FET 21 is connected to a second battery pack 34, which is so loaded that it is removable from the notebook computer body. The source S of the FET 22 is connected to the input terminal of the DC/DC converter 32.

When the keyboard is opened and either of the first battery pack 30 or the second battery pack 34 is removed from the computer body, the electrical connections of the first series circuit 26 to the first battery pack 30 or of the second series circuit 28 to the second battery pack 34 are released. In other words, the first battery pack 30 and the first series circuit 26, and the second battery pack 34 and the second series circuit 28 are so connected that they can be separated.

In the first battery pack 30 are provided a first battery cell 30A, resistors R1, R2, and R3, and a thermistor 30B that monitors the temperature of the first battery cell 30A, i.e., the temperature of the first battery pack 30. A battery temperature T1 is obtained by monitoring the voltage between the resistor R1 and the thermistor 30B, and a battery voltage V1 is read by monitoring the voltage between the resistors R2 and R3. NiMH, etc., can be used as a battery cell.

The arrangement of the second battery pack 34 is identical to that of the first battery pack 30. Provided in the second battery pack 34 are a second battery cell 34A, resistors R4, R5, and R6, and a thermistor 34B that detects the temperature of the second battery cell 34A, i.e., the temperature of the second battery pack 34. As is described for the first battery pack 30, a battery temperature T2 and a battery voltage V2 are respectively obtained by monitoring the voltage between the resistor R4 and the thermistor 34B and the voltage between the resistors R5 and R6.

An AC/DC adaptor 36 that converts an AC (alternate current) into a DC (direct current) is connected to the input terminal of the DC/DC converter 32 via a connector (not shown), which is provided on the side of the computer body, and a diode 40, which is incorporated in the computer body. The AC/DC adaptor 36 can be removed from the computer body by detaching it from the connector.

The anode of the diode 40 is connected to a detection circuit 38 that ascertains whether or not the AC/DC adaptor 36 is connected. When the AC/DC adaptor 36 is connected to the computer system, the detection circuit 38 outputs a high level signal A. When the AC/DC adaptor is removed from the computer system, the detection circuit 38 outputs a low level signal A.

Fig. 3 is a diagram showing a controller 42 that controls the switching of the FETs 11 through 22. Output pins P1, P2, P3 and P4 are connected to the gates G of the individual FETs to input control signals C11, C12, C21, and C22, respectively. Input pins I1 and I2 are so connected that, respectively, they receive the battery voltage V1 and the battery temperature T1. Input pins I4 and I5 are so connected that, respectively, they receive the battery voltage V2 and the battery temperature T2. An input pin I3 is connected to the keyboard switch that serves as a detection means and detects a previous notice for battery removal, and an input pin I6 is so connected that it receives the signal A from the detection circuit 38. The keyboard switch is turned on or off in response to the open or closed state of the keyboard. When a cover other than the keyboard is employed as a cover of the battery storage unit, a switch that is turned on or off in response to the opening or closing the cover may be used instead of the keyboard switch. The controller 42 is connected to a DC power source VCC, and a GND pin is grounded.

Fig. 4 is a flowchart showing the control routine for this embodiment. At step 100, a discharging process for a battery pack is performed to supply power from the bat-

tery pack to the computer. At step 200, a charging process for the battery pack is performed, and at step 300, a process that is initiated when a keyboard is opened, i.e., a process for giving a notice that a battery is to be removed, is performed.

Fig. 5 is a detailed flowchart showing the discharging process for a battery pack at step 100. At step 110, a check is performed to determine whether or not the AC/DC adaptor 36 is connected to the computer system. When the AC/DC adaptor 36 is connected, either a charging process is to be performed, or the computer is being powered by the AC/DC adaptor. The routine is thereafter terminated.

When, at step 110, the AC/DC adaptor 36 is not connected, one of the batteries is discharged, a procedure which will be described later, and when the capacity of this battery falls to or below a predetermined value, the other battery will be discharged.

First, at step 112, a check is performed to determine whether or not the battery voltage V1 of the first battery pack 30 is greater than a reference voltage V0, which is equivalent to the operation halt voltage for a battery. The reference voltage V0 is employed to halt the battery discharging when the battery voltage V1 is reduced to the reference voltage V0 or lower. When the battery voltage V1 is greater than the reference voltage V0, the discharging is enabled. At step 114, therefore, a check is performed to determine whether or not the first battery pack 30 is being discharged. When the first battery pack 30 is being discharged, the routine is terminated. If it is determined that the first battery pack 30 is not discharging, the discharge of the first battery pack 30 is initiated, as will be described later, at step 116.

When the battery voltage V1 of the first battery pack 30 is the reference voltage V0 or below, i.e., when the normal discharging of the first battery pack 30 cannot be performed, a check is then performed at step 118 to determine whether or not the battery voltage V2 of the second battery pack 34 is greater than the reference voltage V0. If the battery voltage V2 is greater than the reference voltage V0, at step 120 a check is performed to determine whether or not the second battery pack 34 is being discharged. If the second battery pack 34 is being discharged, the routine is terminated. If the second battery pack 34 is not being discharged, the discharge of the second battery pack 34 is initiated, at step 122, as will be described later.

When, at step 118, the battery voltage V2 is equal to or lower than the reference voltage V0, i.e., when the normal discharge of the first battery pack 30 and the second battery pack 34 cannot be performed, it is assumed that the capacities of both batteries are equal to or lower than a predetermined value. An LED is switched on to indicate the remaining battery capacities are low and the computer is set to the suspended state and powered down. While the computer is in the suspended state, power is supplied to electronic components, such as a memory and a memory controller, but no power is sup-

plied to a display, etc.

Fig. 6 is a detailed flowchart for the procedure at step 116. At step 116A, a check is performed to determine whether or not the second battery pack 34 is being discharged. If the second battery pack 34 is not being discharged, it is assumed that the second battery pack 34 is not in use while the first battery pack 30 is in use. At step 116E, therefore, the controller 42 outputs control signals C11, C12, C21, and C22 for turning on the FETs 11 and 12 and for turning off the FETs 21 and 22 (Fig. 8). Then, the discharge of the first battery pack 30 is performed to supply power to the computer body. Since electric power from the first battery pack 30 is supplied without the internal diodes D11 and D12, the power loss that results from the use of the diodes does not occur. Although power is supplied via the FETs in this case, compared with power that is lost when the internal diodes are in use, the power loss due to the resistance in the FETs is so low that it can be disregarded. The supply of power from the second battery pack 34 is stopped by the diode D22 (when $V2 > V1$, as is shown in Fig. 8) or by the diode D21 ($V1 > V2$, as is shown in Fig. 16).

If, at step 116A, the second battery pack 34 is being discharged, the FETs 11 and 12 are off and the FETs 21 and 22 are on (Fig. 12). At step 116B, the FET 21 is then turned off. The control signals outputted by the controller 42 are: C11 = off, C12 = off, C21 = off, and C22 = on. Consequently, power is supplied from the second battery pack 34 via the internal diode D21 and the drain-source of the FET 22 (Fig. 11).

At step 116C, the FET 12 is turned on. The control signals at this period are: C11 = off, C12 = on, C21 = off, and C22 = on. Consequently, the first battery pack 30 and the second battery pack 34 are set to the diode-OR state for the DC/DC converter 32, with power being supplied from the first battery pack 30 via the internal diode D11 and the drain-source of the FET 12, and from the second battery pack 34 via the internal diode D21 and the drain-source of the FET 22 (Fig. 10).

At the next step 116D, the FET 22 is turned off. The control signals at this period are: C11 = off, C12 = on, C21 = off, and C22 = off. As a result, the supply of power from the second battery pack 34 is halted by the internal diode D22 and only power from the first battery pack 30 is supplied. At step 116E, the FET 11 is turned on. Then, power from the first battery pack 30 is supplied via the source-drain of the FET 11 and the drain-source of the FET 12, and does not pass through the internal diode D11 of the FET 11 and the internal diode D12 of the FET 12.

Fig. 7 is a detailed flowchart for the procedure at step 122. At step 122A, a check is performed to determine whether or not the first battery pack 30 is being discharged. If the first battery pack 30 is not being discharged, at step 122E the FETs 11 and 12 are turned on and the FETs 21 and 22 are turned off (Fig. 12). Thus, power from the second battery pack 34 is supplied to the computer body without passing through the internal di-

odes D21 and D22, and the power loss that results from the use of the internal diodes does not occur.

If, at step 122A, the first battery pack 30 is being discharged, the FET 11 is turned off at step 122B, the FET 22 is turned on at step 122C (set to the diode-OR state), the FET 12 is turned off at step 122D, and the FET 21 is turned on at step 122E. The control signals from the controller 42 at this period are shown at steps 122B through 122E in Fig. 7. The battery switching that is performed in consonance with the flowchart in Fig. 7 is illustrated in Figs. 8 through 12. The state where the first battery pack 30 is being discharged is shown in Fig. 8. Figs. 9 through 12 correspond to steps 122B through 122E, respectively.

As described above, by switching from the second battery pack 34 to the first battery pack 30, or from the first battery pack 30 to the second battery pack 34, power can be constantly supplied to the computer body. Since this battery switching is performed substantially instantaneously, the power loss that is caused by the internal diodes (D11, D12, D21, and D22) is so small that it can be disregarded.

Fig. 13 is a detailed flowchart for the procedure at step 200. At step 210, a check is performed to determine whether or not the AC/DC adaptor 36 is connected. When the AC/DC adaptor 36 is not connected, charging cannot be performed. The routine is therefore terminated.

If, at step 210, the AC/DC adaptor 36 is connected, one of the batteries is charged, as will be described later. When this battery is fully charged, the charging of the other battery is begun.

First, at step 212, a check is performed to determine whether or not the charging start condition for the second battery pack 34 is established. For the charging start condition in this case, the battery temperature must be within a predetermined range (for example, $5^{\circ}\text{C} < \text{battery temperature} < 43^{\circ}\text{C}$) and the battery voltage is equal to or lower than a battery charge start voltage (which may be the same as the reference voltage $V0$). When these requirements are satisfied, the charging start condition is established.

When the charging start condition for the second battery pack 34 is established, the charging is begun at step 214, as will be described later. When the charging start condition for the second battery pack 34 is not established, at step 216, a check is performed, by referring to the above described requirements, to determine whether or not the charging start condition for the first battery pack 30 is established. When the charging start condition for the first battery pack 30 is established, the charging is begun at step 218, as will be described later.

At step 220, a check is performed to determine whether or not the second battery pack 34 is being charged. If the second battery pack 34 is being charged, a check is performed at step 222 to determine whether or not the second battery pack 34 has been fully charged. A measured increase in the battery temperature since the beginning of the charging, or the attainment of a

specified battery temperature is employed for this determination. When the battery temperature has risen a predetermined number of degrees (e.g., 22°C) or more since the beginning of the charging, or when the battery temperature reaches a specific value (e.g., 60°C), the second battery pack 34 is determined to have been fully charged.

When the second battery pack 34 has been fully charged, at step 224 the control signal C21 is output to the gate and the FET 21 is turned off to halt the charging of the second battery pack 34. If, at step 220, the second battery pack 34 is not being charged, a check is performed at step 226 to determine whether or not the first battery pack 30 is being charged. If the first battery pack 30 is being charged, at step 228 a check is performed, by referring to the above described requirements, to determine whether or not the first battery pack 30 has been fully charged. When the first battery pack 30 has been fully charged, the control signal C11 is output to the gate and the FET 11 is turned off, thus halting the charging of the first battery pack 30.

Fig. 16 is a diagram showing how power is supplied from the first battery pack 30. When the AC/DC adaptor 36 is connected to the circuit in this state, and the charging start condition for the first battery pack 30 is established, the charging for the first battery pack 30 is initiated, as is shown in Fig. 17 (step 218). When the first battery pack 30 is fully charged, the charging for the first battery pack 30 is halted, as is shown in Fig. 18 (step 230).

Fig. 14 is a detailed flowchart for the procedure at step 214 where the second battery pack 34 is to be charged. When the charging start condition for the second battery pack 34 is established, the charging of the first battery pack 30 is completed, and the FET 11 is in the off state, the FET 12 is in the on state, the FET 21 is in the off state, and the FET 22 is in the on state (Fig. 18). Therefore, the FET 22 is turned on at step 214A (Fig. 19), the FET 12 is turned off at step 214B (Fig. 20), and the FET 21 is turned on at step 214C (Fig. 21). The charging for the second battery pack 34 is then begun. It should be noted that, at steps 214A through 214C in Fig. 16, the states of the FETs are described by the ON/OFF control signals C11 through C22 that are carried to the gates.

Fig. 15 is a detailed flowchart for the procedure at step 218 where the first battery pack 30 is to be charged. When the charging for the second battery pack 34 is halted at step 224, the FETs 11, 12, and 21 are in the off state and the FET 22 is in the on state. Therefore, the FET 12 is turned on at step 218A, the FET 22 is turned off at step 218B, and the FET 11 is turned on at step 218C.

Since, as described above, the charging and the discharging processes are performed by using a common route for the power supply and the charging, a battery connecting device having a simple structure is provided.

Fig. 22 is a detailed flowchart for the procedure at

step 300. At step 310, a check is performed to determine whether or not the keyboard was opened in consonance with a signal from the keyboard switch, i.e., whether or not a previous notice that a battery is to be removed was issued. When the keyboard is opened, it is assumed that a previous notice has been issued. At step 312, therefore, the first battery pack 30 and the second battery pack 34 are set to the diode-OR state with respect to the DC/DC converter 32. More specifically, to supply power from the first battery pack 30, the FET 11 is turned off and the FET 22 is turned on. To supply power from the second battery pack 34, the FET 21 is turned off and the FET 12 is turned on. Even if one of the batteries is removed, power can be supplied from the remaining battery. Although at this period power is to be supplied via the diode, the replacement of a battery can be completed within a short period of period and there is therefore very little power loss.

Then, at step 314, a check is performed to determine whether or not the keyboard has been closed. When the keyboard is closed, the routine is terminated.

Although in this embodiment the batteries are connected individually to two series circuits, three or more series circuits may be employed and the batteries may be connected to each of the series circuits. Further, although the FETs are employed as switching elements, other switching elements, such as transistors or relays, may be employed. In addition, although the issuance of the previous notice for battery removal is detected upon the opening of the keyboard, the issuance of such a previous notice may be detected by determining whether the battery capacity is equal to or lower than a predetermined value.

Moreover, although the FET employed in this embodiment has a diode which has its anode connected to the source of the FET and its cathode connected to the drain, the present invention is not limited to the thus arranged FET, and an FET where the cathode of a diode is connected to the source may be used.

As described above, according to claims 1 through 4 of the present invention, the power loss that is caused by diodes can be eliminated and the operating period when using a battery can be extended.

The operating period for a battery can be extended, and batteries that are being discharged can be switched without halting the power supply when the capacity of one of the batteries is decreased.

Since a route for the power supply is a common route that is also used for charging, a battery connecting device that has a simple structure can be provided and batteries that are being charged can be smoothly switched.

Since the battery connecting device is in the diode-OR state when a previous notice that indicates a battery is to be removed is detected, the operating period for a battery can be extended, and halting of the power supply, which is ascertained by the removal of a battery, can be prevented.

Claims

1. A battery connecting device, for a computer, comprising:

a plurality of series circuits including
 a first series circuit (26), which includes a first circuit and a second circuit, and with said first circuit having a first switching element (FET11), which is connectable separably to a first battery (30) at an input terminal, and a first diode (D11), which has an anode connected to the input terminal of said first switching element (FET11) and a cathode connected to the output terminal of said first switching element (FET11), and with said second circuit having a second switching element (FET12), which has an input terminal connected to the output terminal of said first switching element (FET11) and an output terminal connectable to the computer to supply power thereto, and a second diode (D12), which has a cathode connected to the input terminal of said second switching element (FET12) and an anode connected to the output terminal of said second switching element (FET12);

a second series circuit (28), which includes a third circuit and a fourth circuit, and with said third circuit having a third switching element (FET21), which is connectable separably to a second battery (34) at an input terminal, and a third diode (D21), which has an anode connected to the input terminal of said third switching element (FET21) and a cathode connected to the output terminal of said third switching element (FET21), and with said fourth circuit having a fourth switching element (FET22), which has an input terminal connected to the output terminal of said third switching element (FET21) and an output terminal connectable said computer to supply power thereto, and a fourth diode (D22), which has a cathode connected to the input terminal of said fourth switching element (FET22) and an anode connected to the output terminal of said fourth switching element (FET22); and

control means for switching said switching elements (FET11, FET12, FET21, FET22) between ON and OFF states in a predeterminable order according to a predeterminable conditions.

2. A battery connection device as claimed in claim 2, wherein said conditions are the capacities of said first and second batteries, and further comprising detection means for detecting the capacities of said first and second batteries, and wherein

said control means comprises means for turning on said first and said second switching element and for turning off said third and said fourth switching element in order to supply power to said computer body from said first battery, and for, when the capacity of said first battery falls to or below a predetermined value, turning off said first switching element,

turning on said fourth switching element, turning off said second switching element, and turning on said third switching element, in the named order, in order to supply power from said second battery to said computer body.

3. A battery connection device as claimed in any preceding claim, further comprising a converter (36), for converting an alternate current into a direct current, connectable to said output terminals of said second (FET12) and fourth (FET22) switching elements;

determination means for determining a charging initiation condition of said first and second batteries; and

control means, responsive to said determination means, for starting charging of said batteries while said converter is connected to said terminals, and for, when said first battery is fully charged and the charging start condition for said second battery is established, turning off said first switching element, turning on said fourth switching element, turning off said second switching element, and turning on said third switching element, in the named order, to initiate charging of said second battery.

4. A battery connection device as claimed in any preceding claim, further comprising:

detection means for detecting a previous notice for battery removal while batteries are connected to at least two of said plurality of series circuits; and

control means for, when power is being supplied from one battery and a previous notice for battery removal is detected, controlling the ON/OFF states of said first and said second switching element so as to supply power from two or more batteries to said computer body via said first diode.

5. A method for switching two batteries, which are connected to paired series circuits of a battery connecting device for a computer system, each of which series circuits includes a first circuit and a second circuit, with said first circuit having a first switching element, which is connectable to a battery at an input terminal, and a first diode, which has an anode connected to the input terminal of said first switching element and a cathode connected to the output terminal of said first switching element, and with said second circuit having a second switching element, which has an input terminal connected to the output terminal of said first switching element and an output terminal connected to a computer body to supply power, and a second diode, which has a cathode connected to the input terminal of said second switching element and an anode connected to the output terminal of said second switching element, comprising the steps of:

supplying power from one battery to the com-

puter via said first and said second switching elements of one of said series circuits, while supplying power from both of the batteries to said computer via the first diode:

halting the power supply from said battery to said computer body; and

supplying power from the other battery to a computer body via said first and said second switching element of the other series circuit.

6. A method of switching batteries according to claim 5, wherein one battery is switched to the other battery when a voltage of one of the batteries falls to or below a predetermined value.

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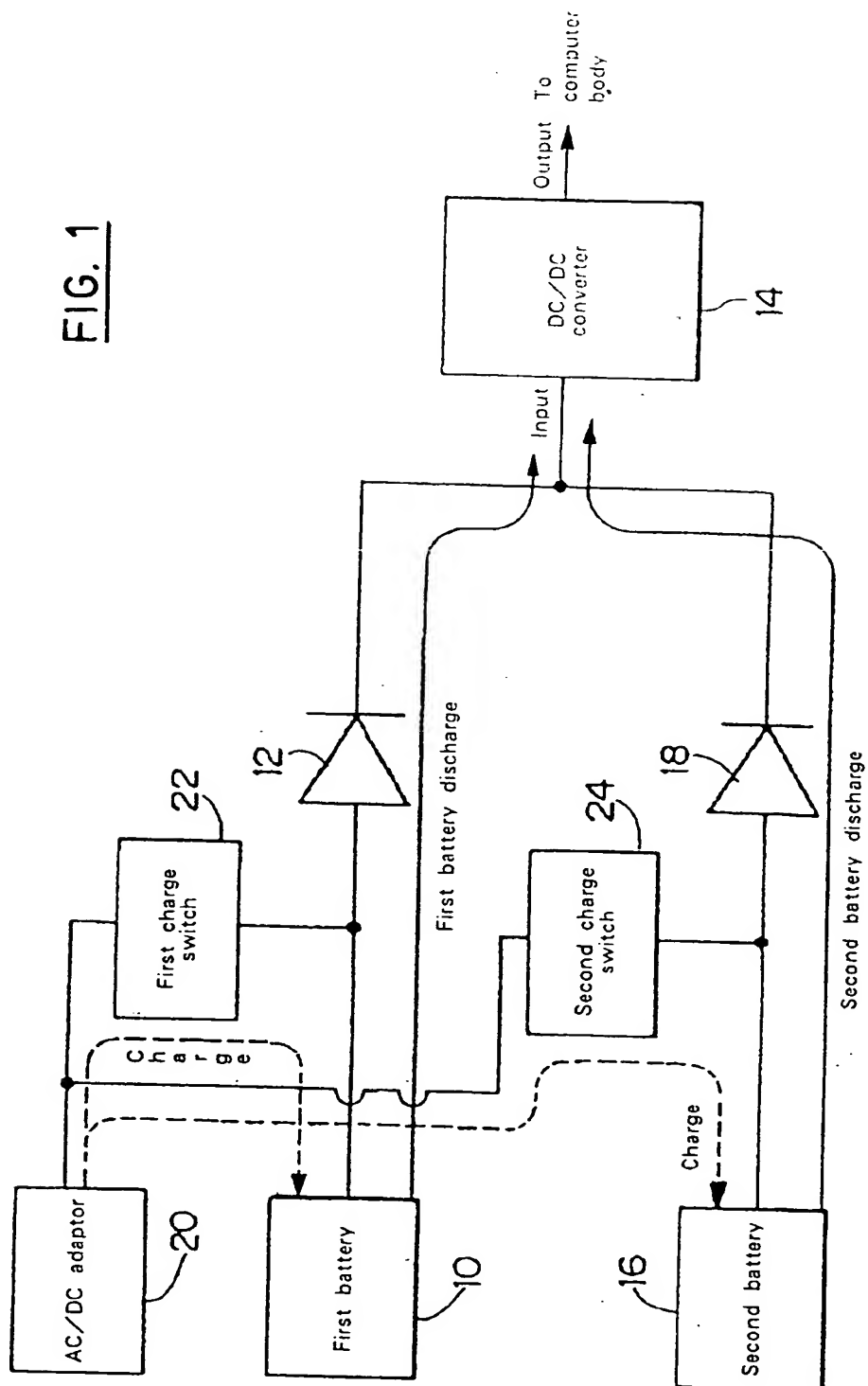
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FIG. 1



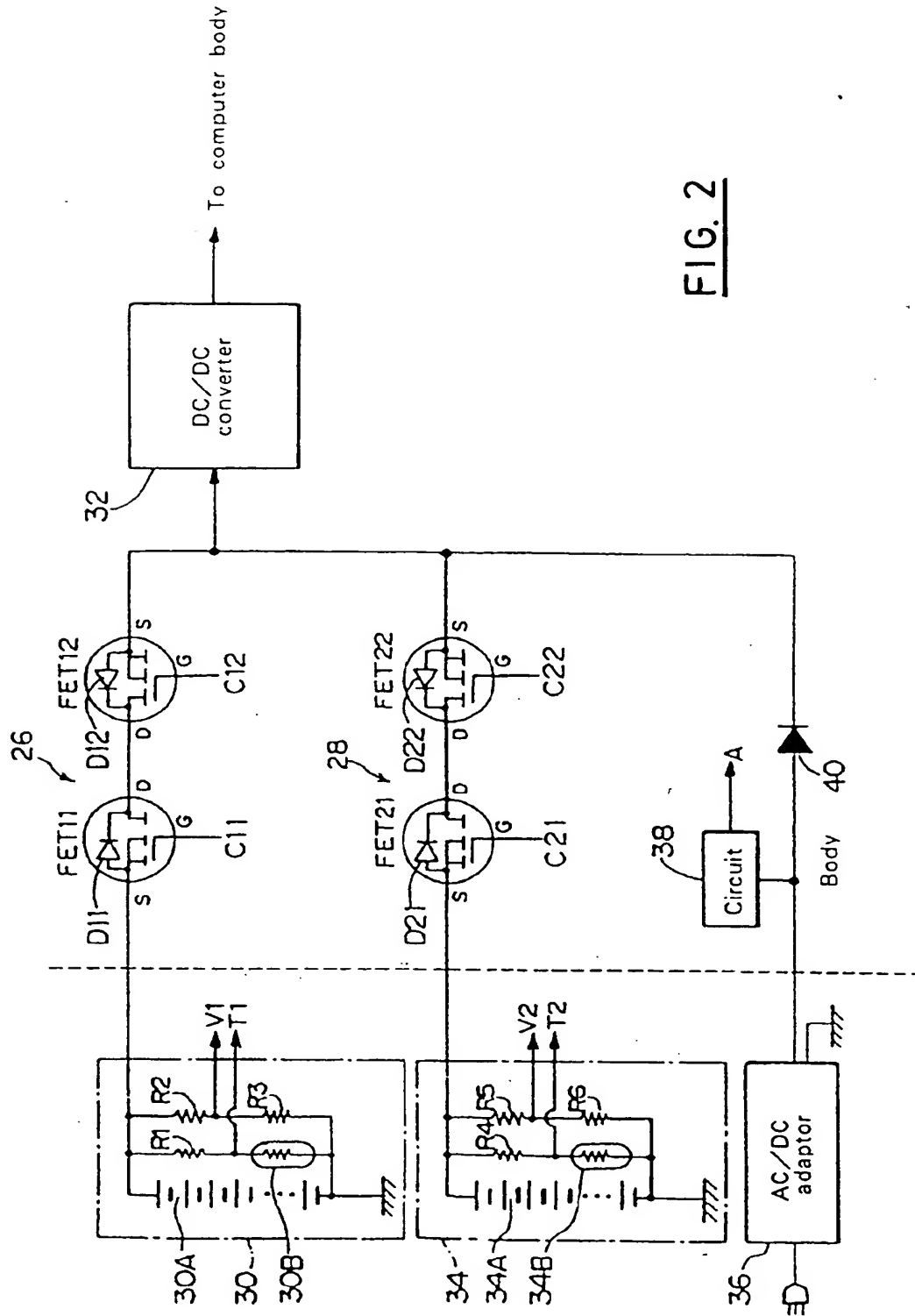


FIG. 2

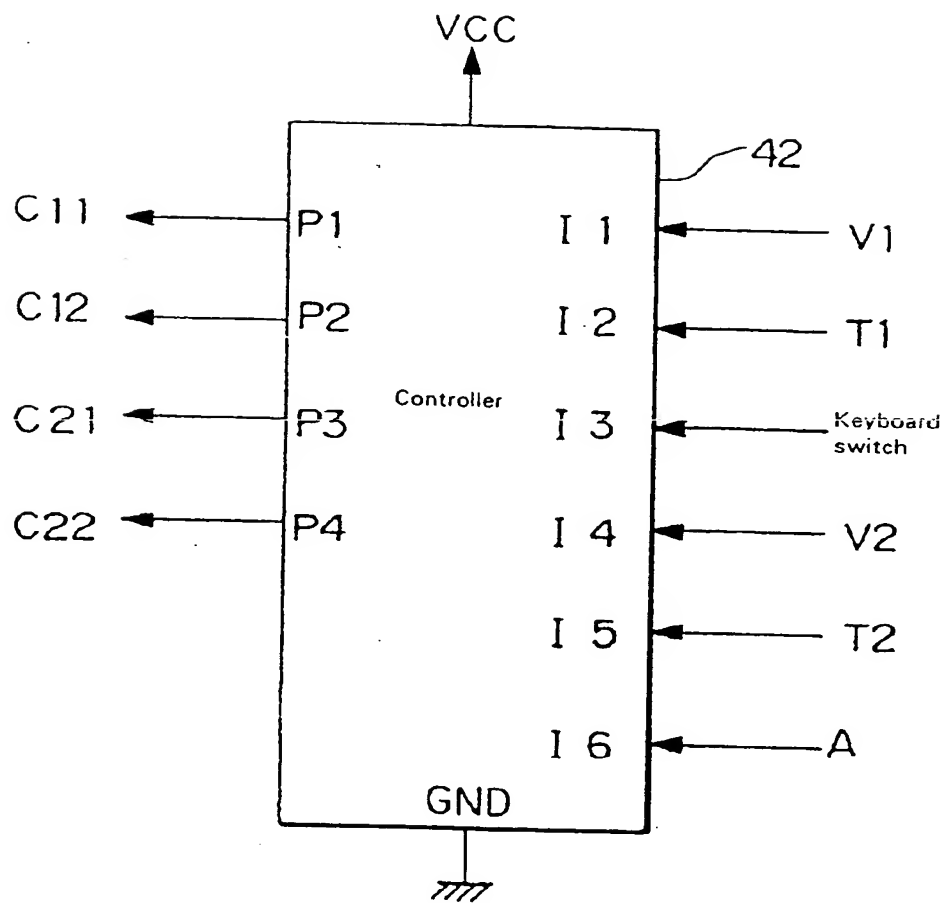


FIG. 3

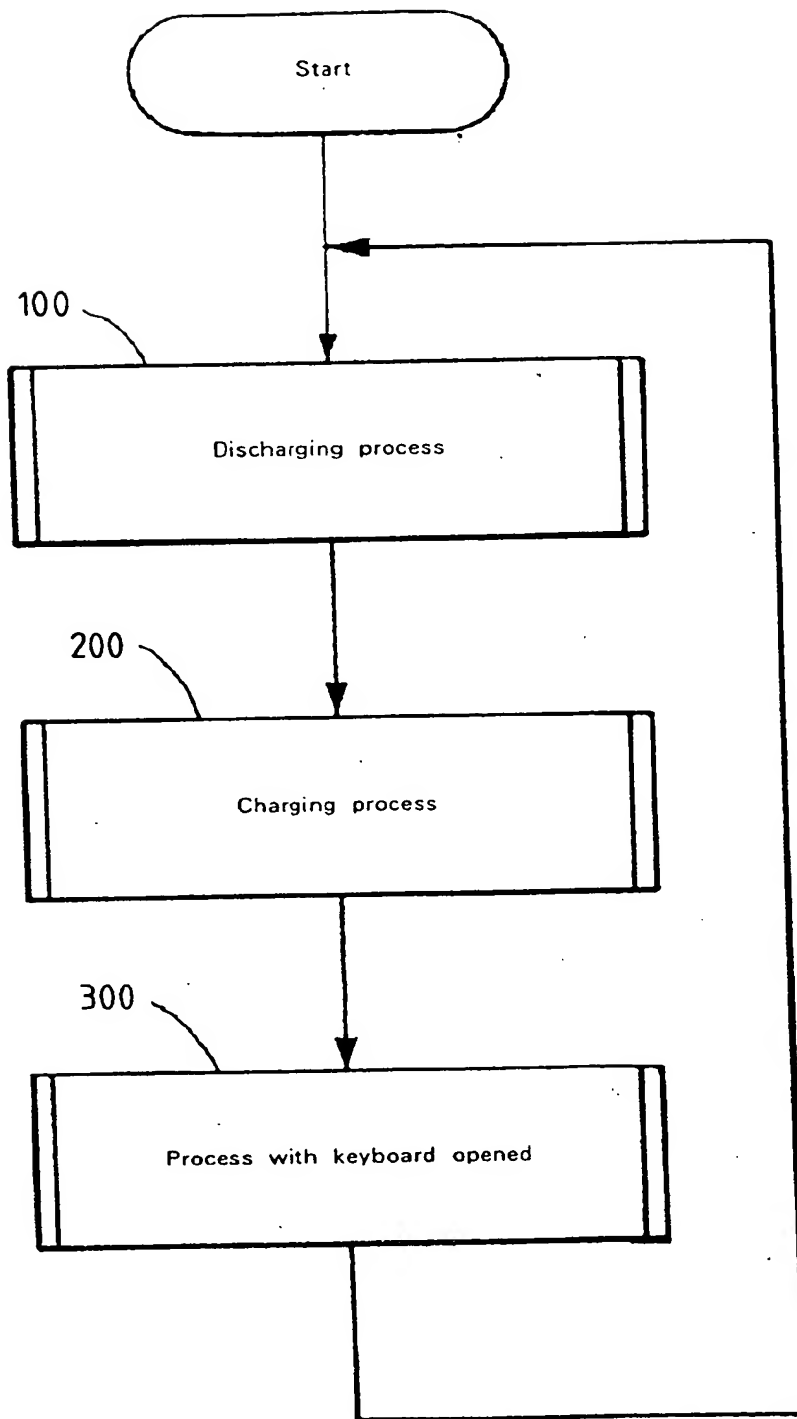
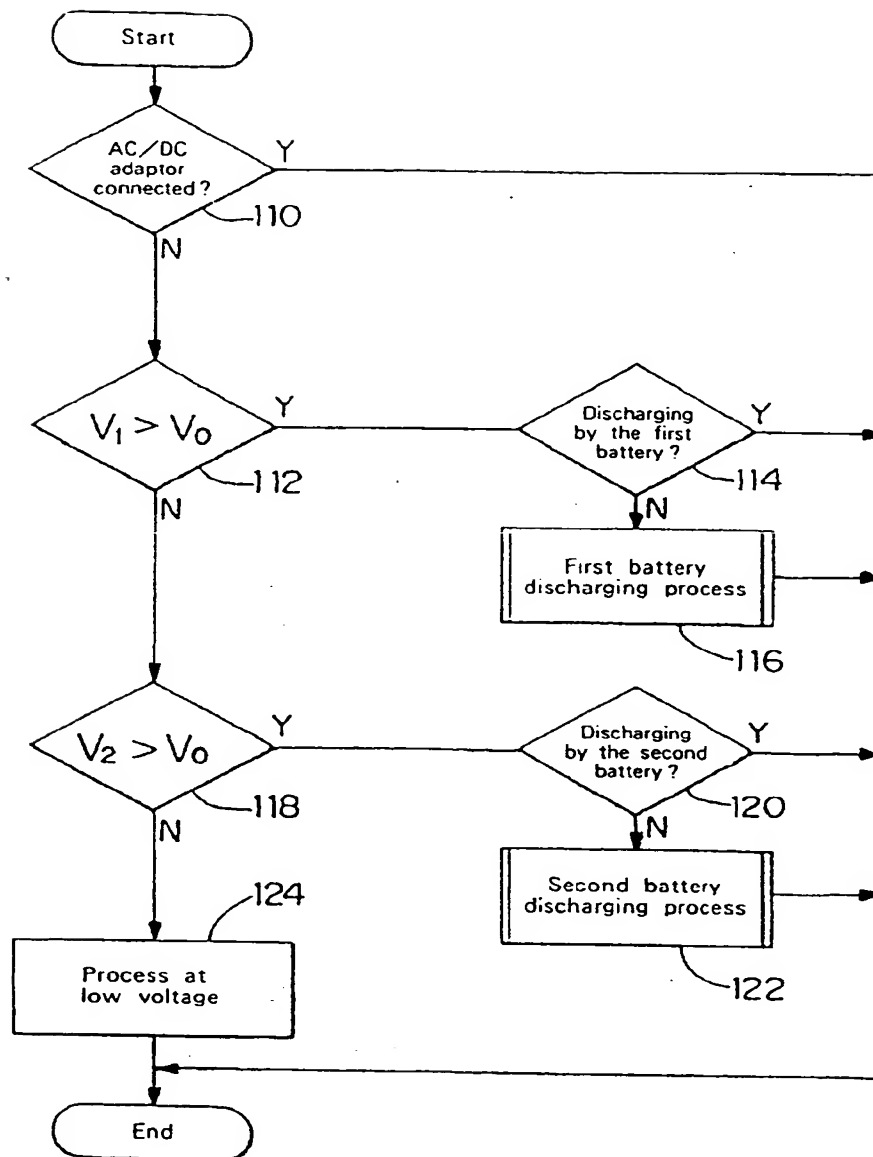
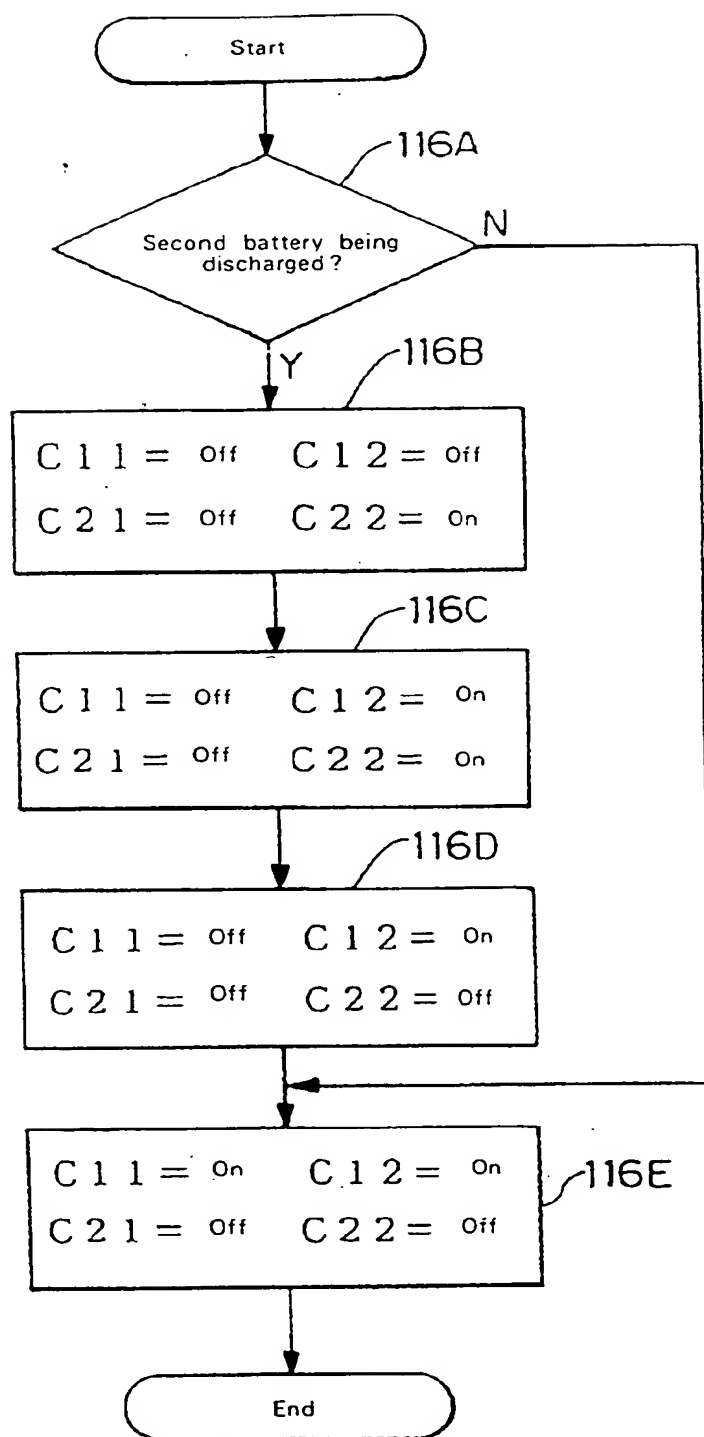
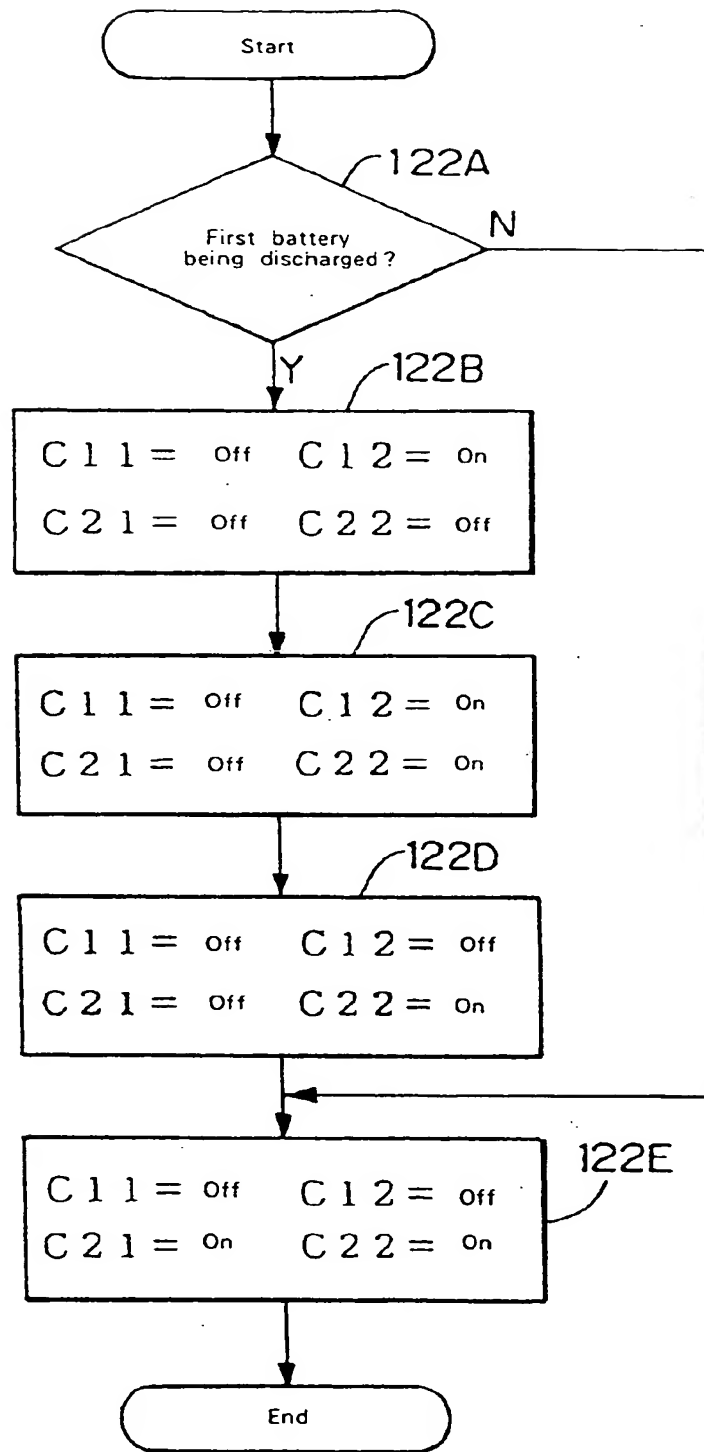


FIG. 4

FIG. 5

**FIG. 6**

**FIG. 7**

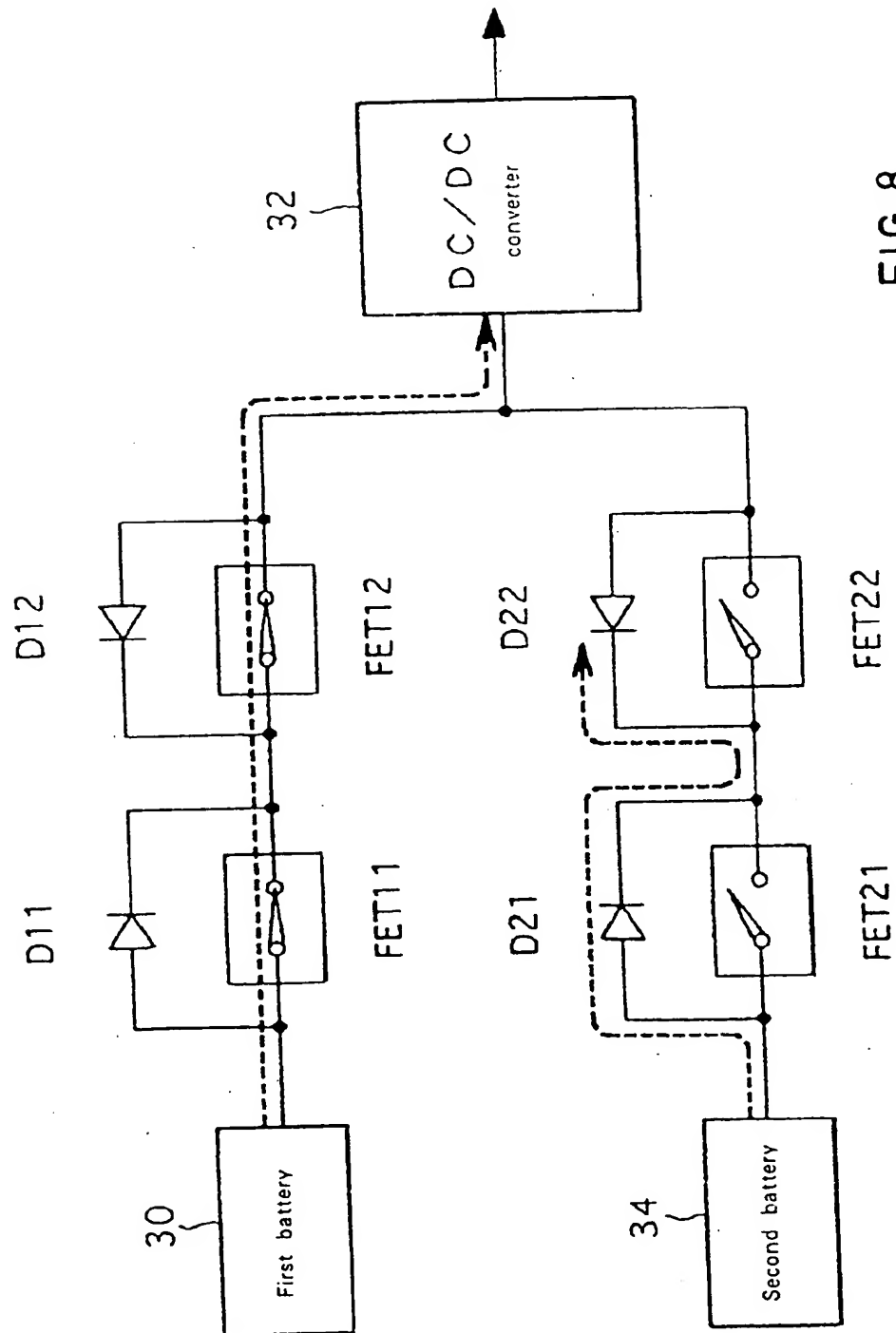
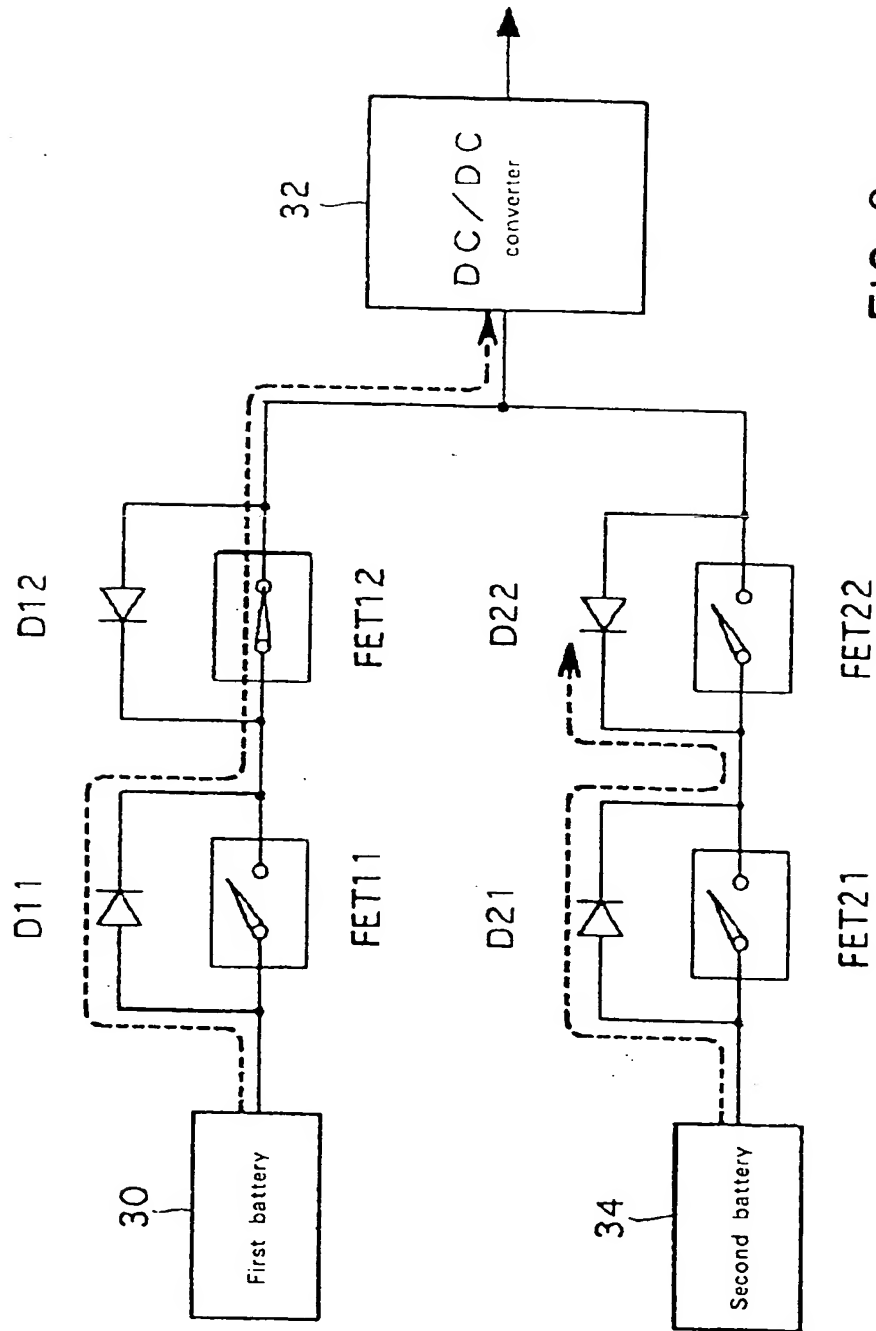


FIG. 8

FIG. 9

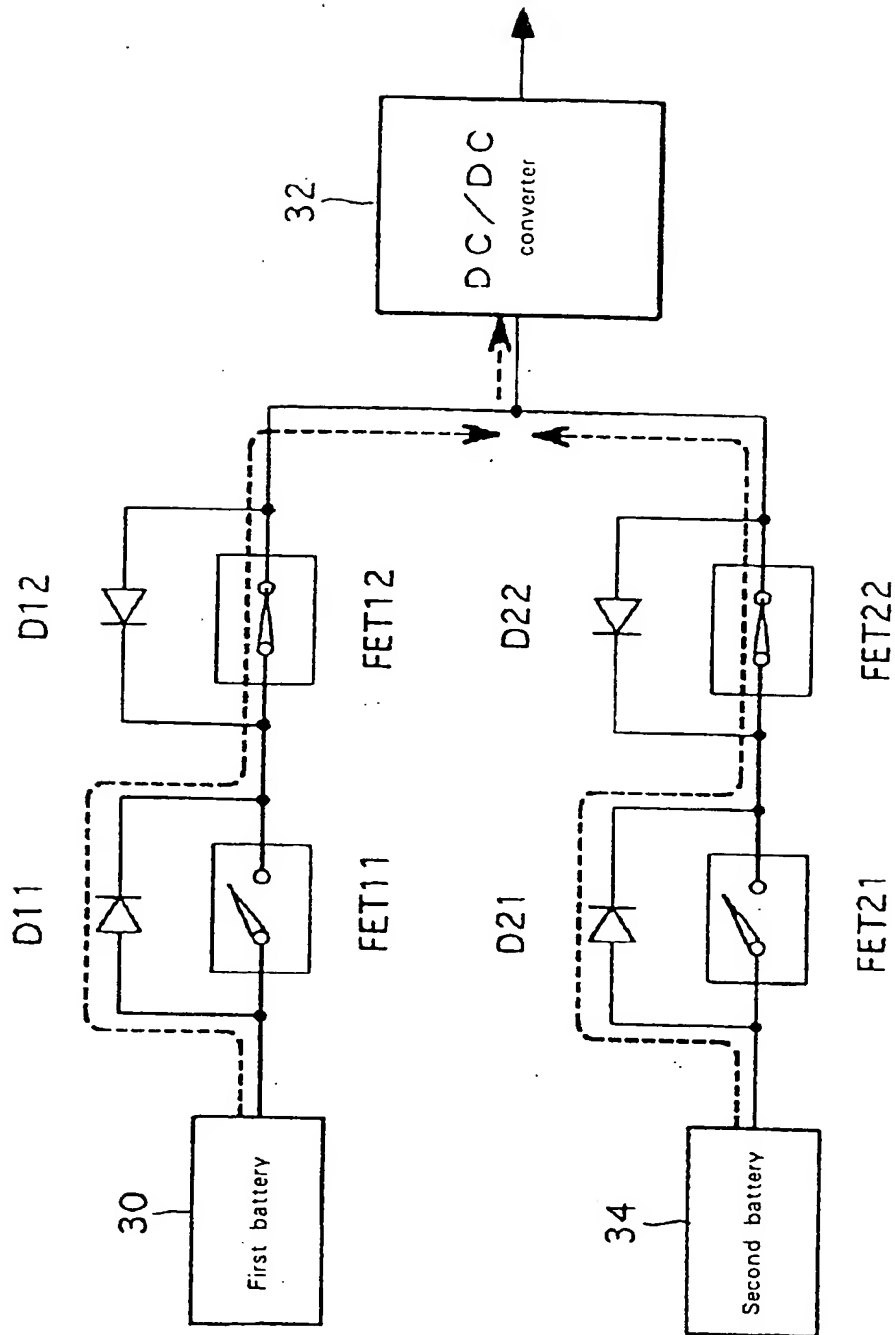


FIG. 10

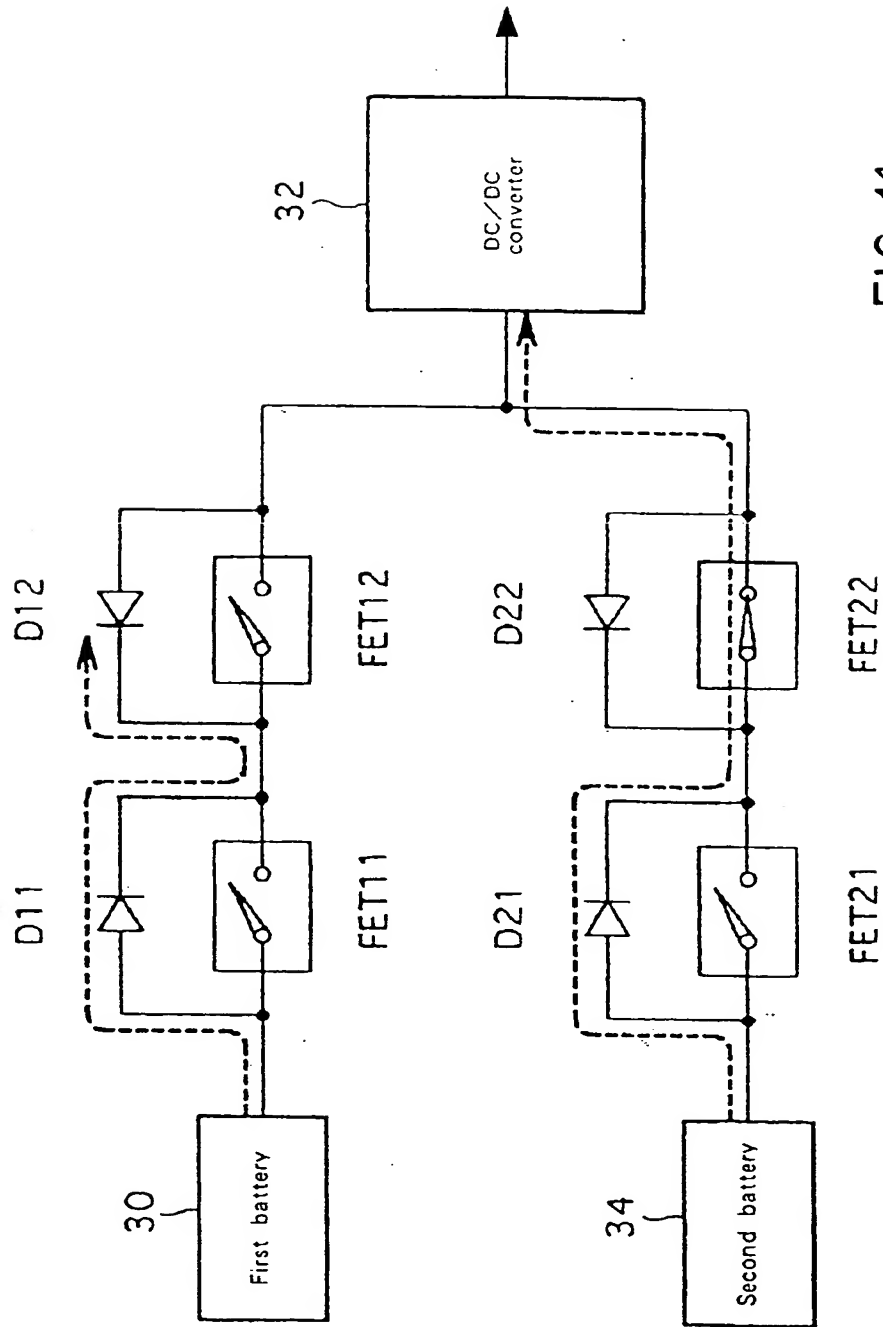


FIG. 11

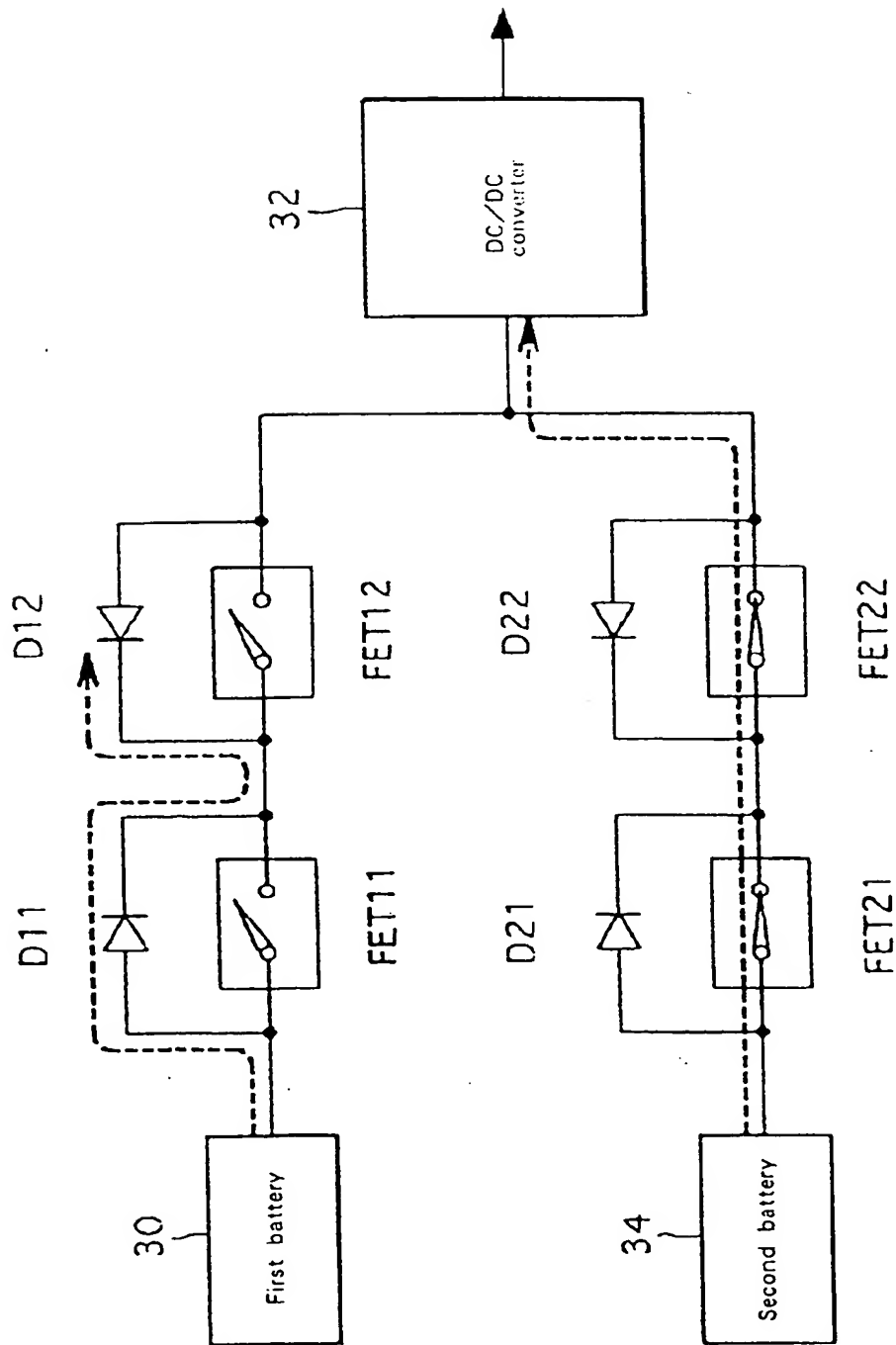
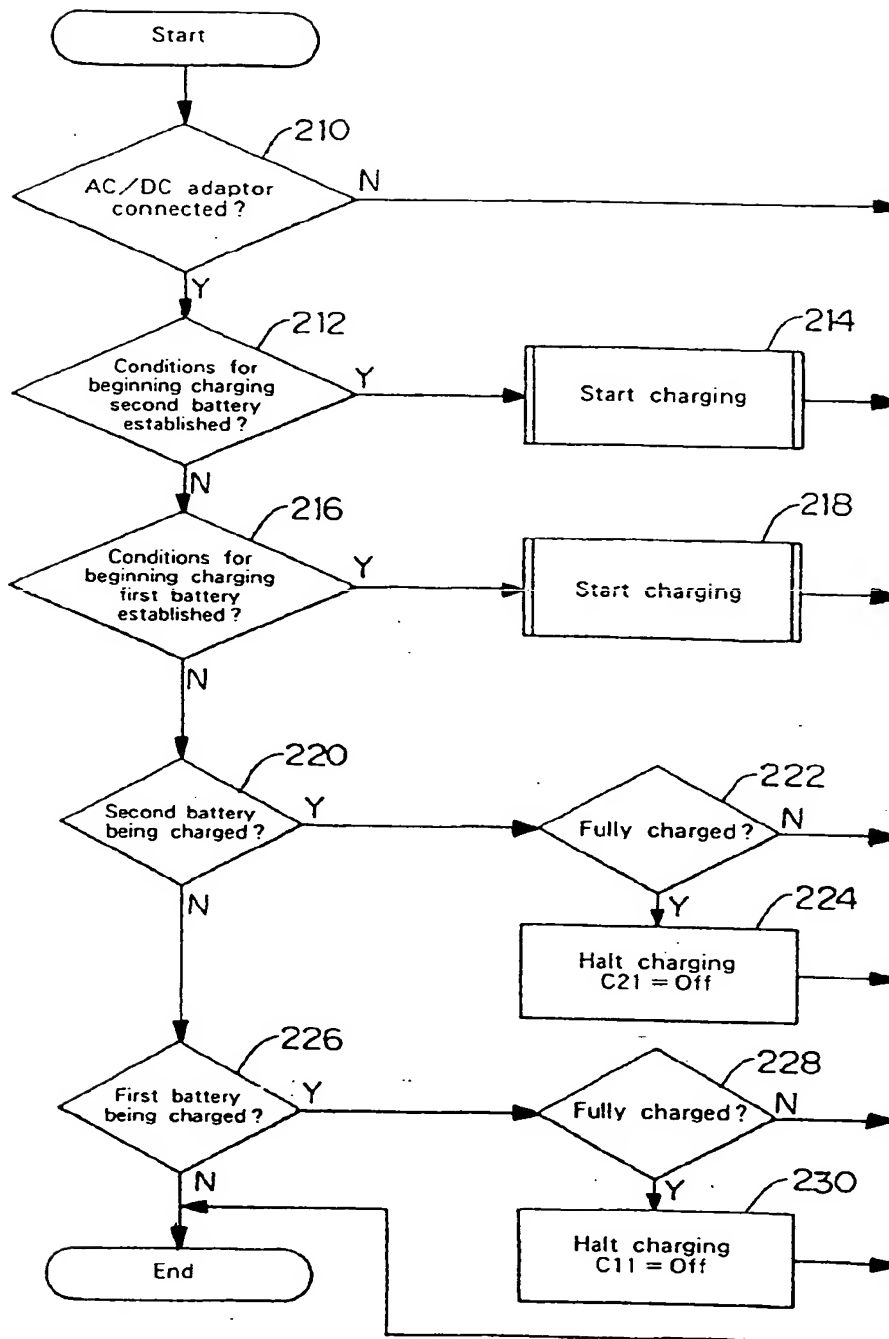
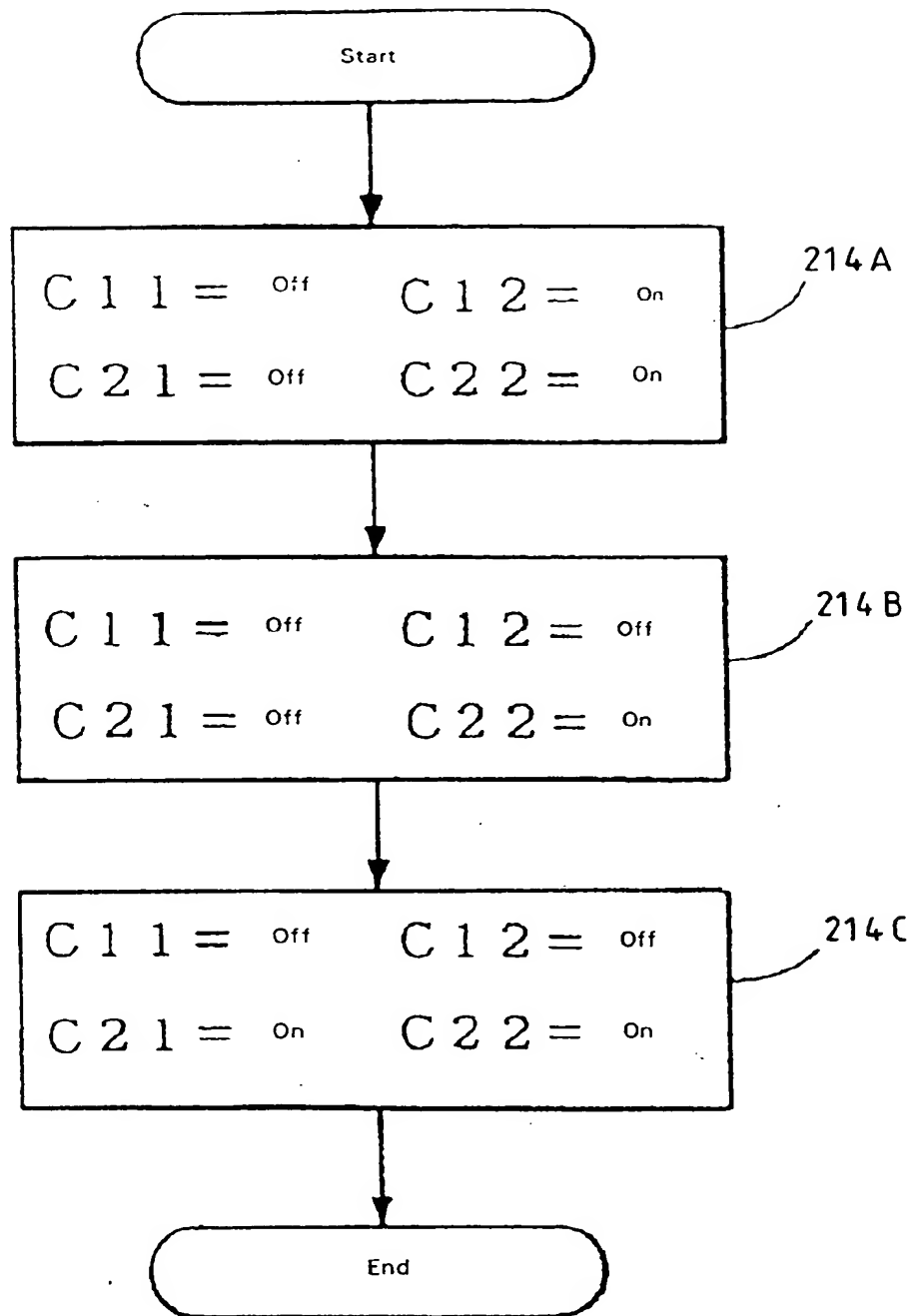
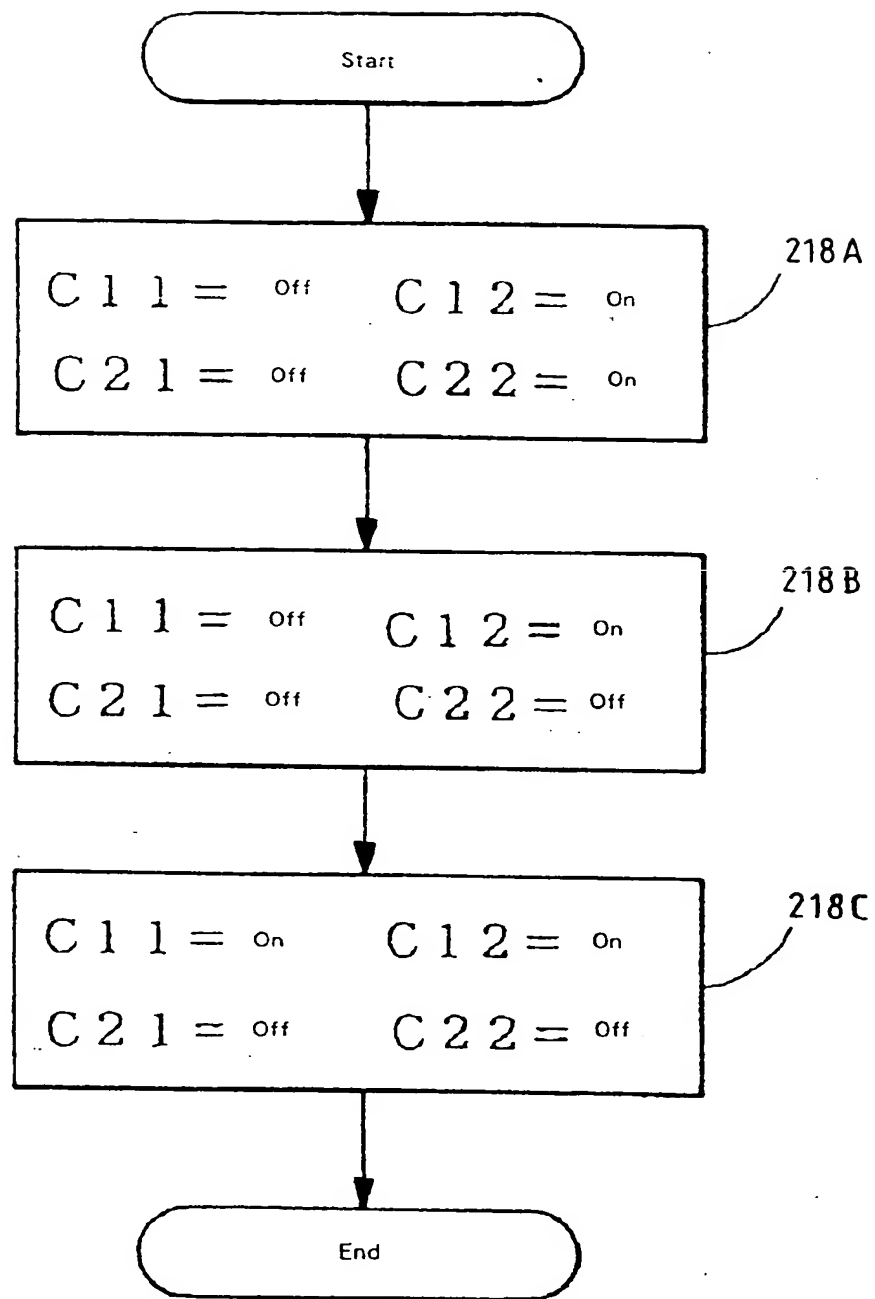


FIG. 12

**FIG. 13**

FIG. 14

FIG. 15

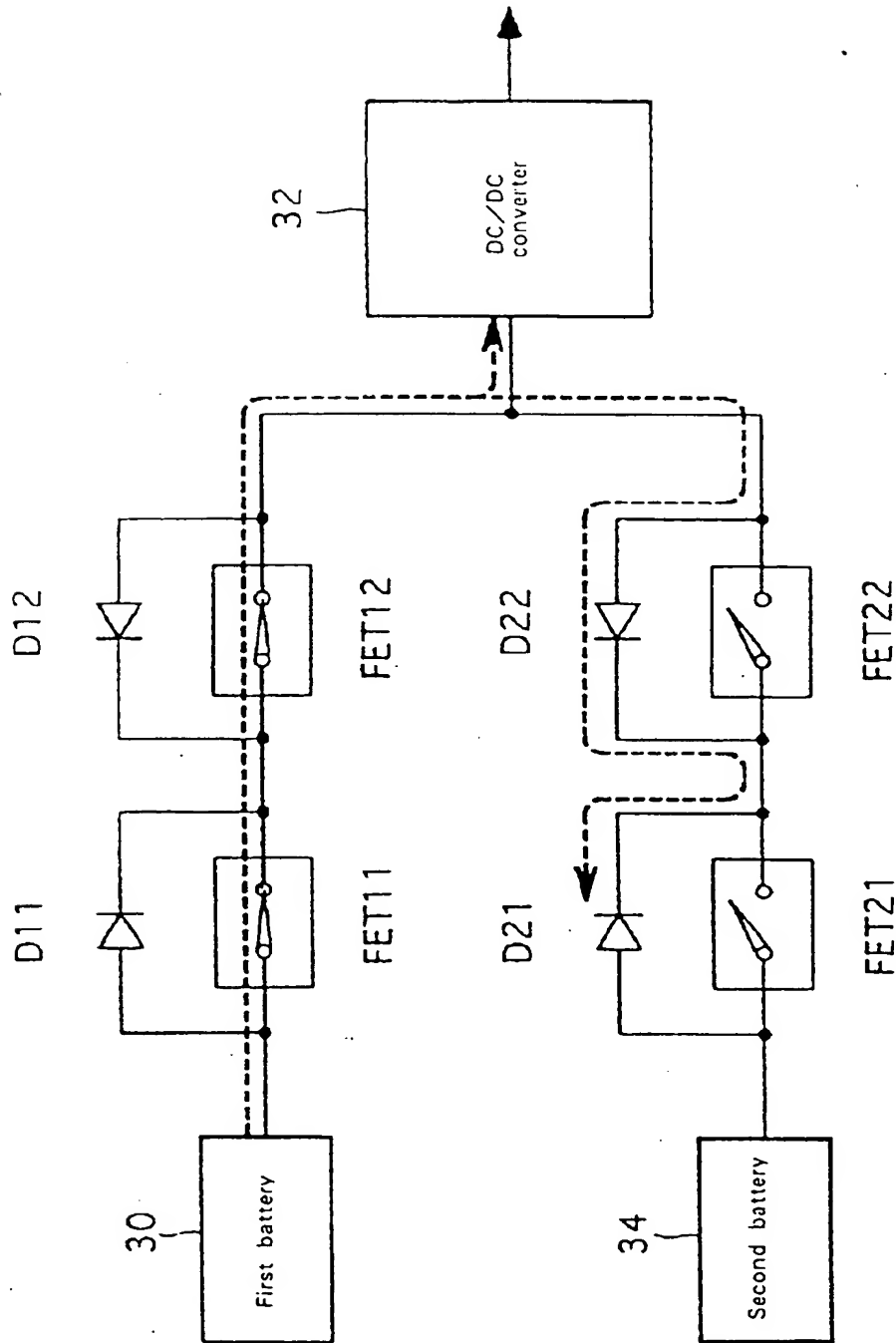


FIG. 16

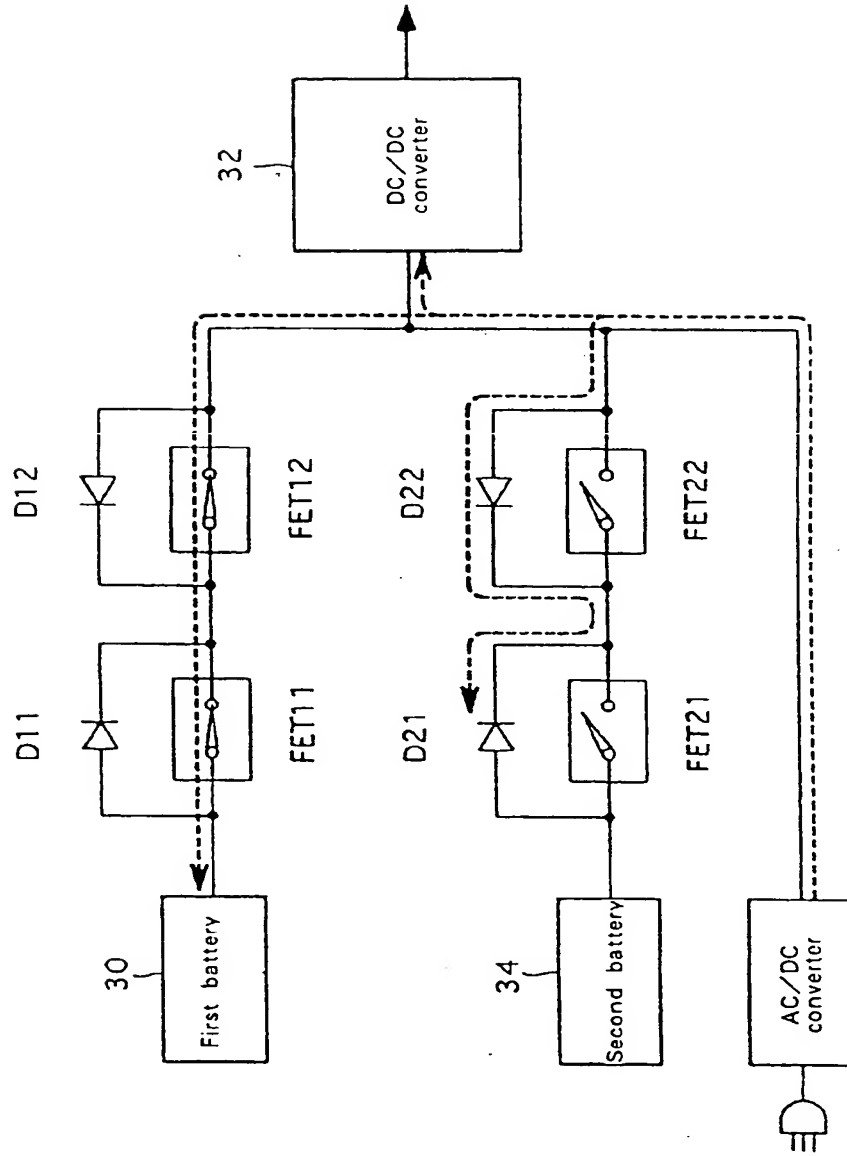


FIG. 17

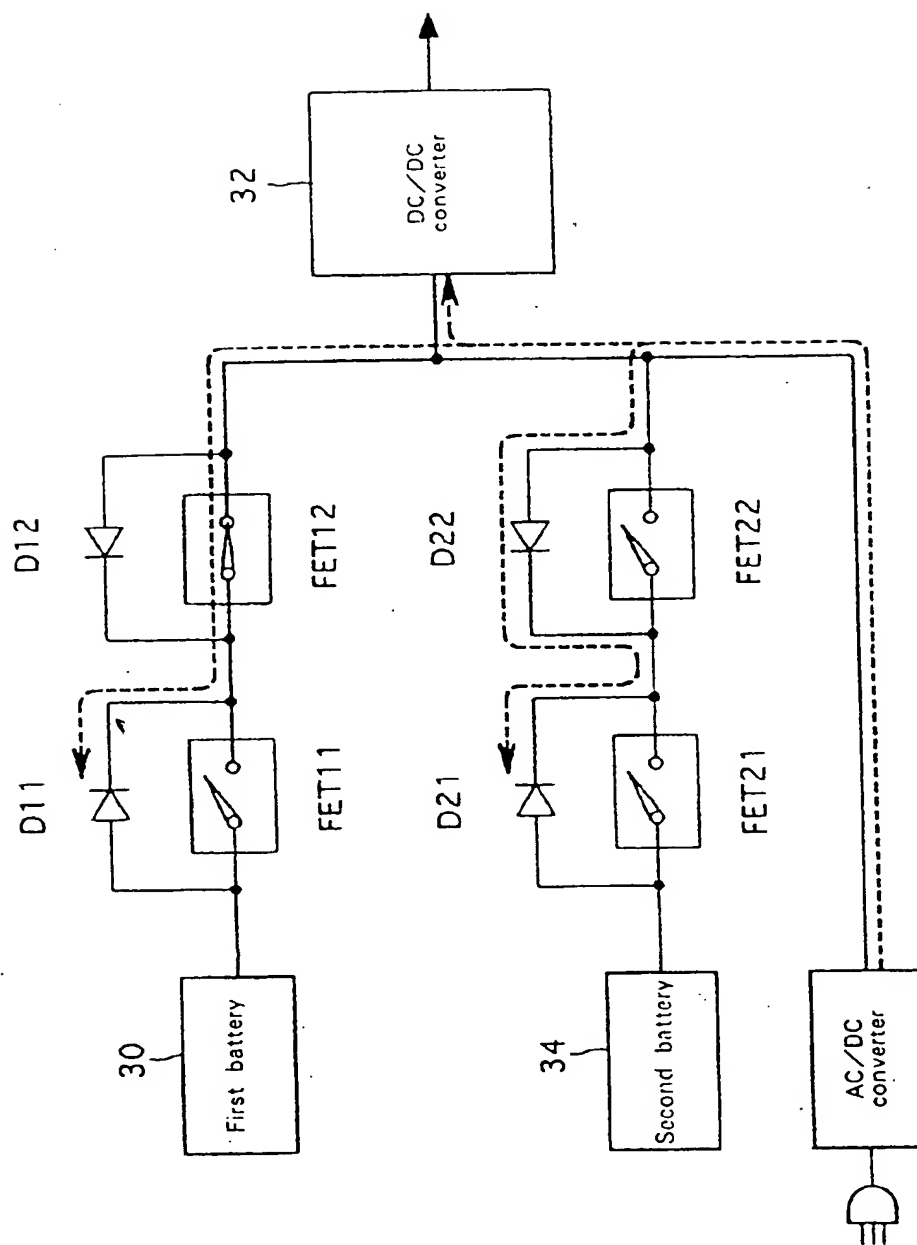


FIG. 18

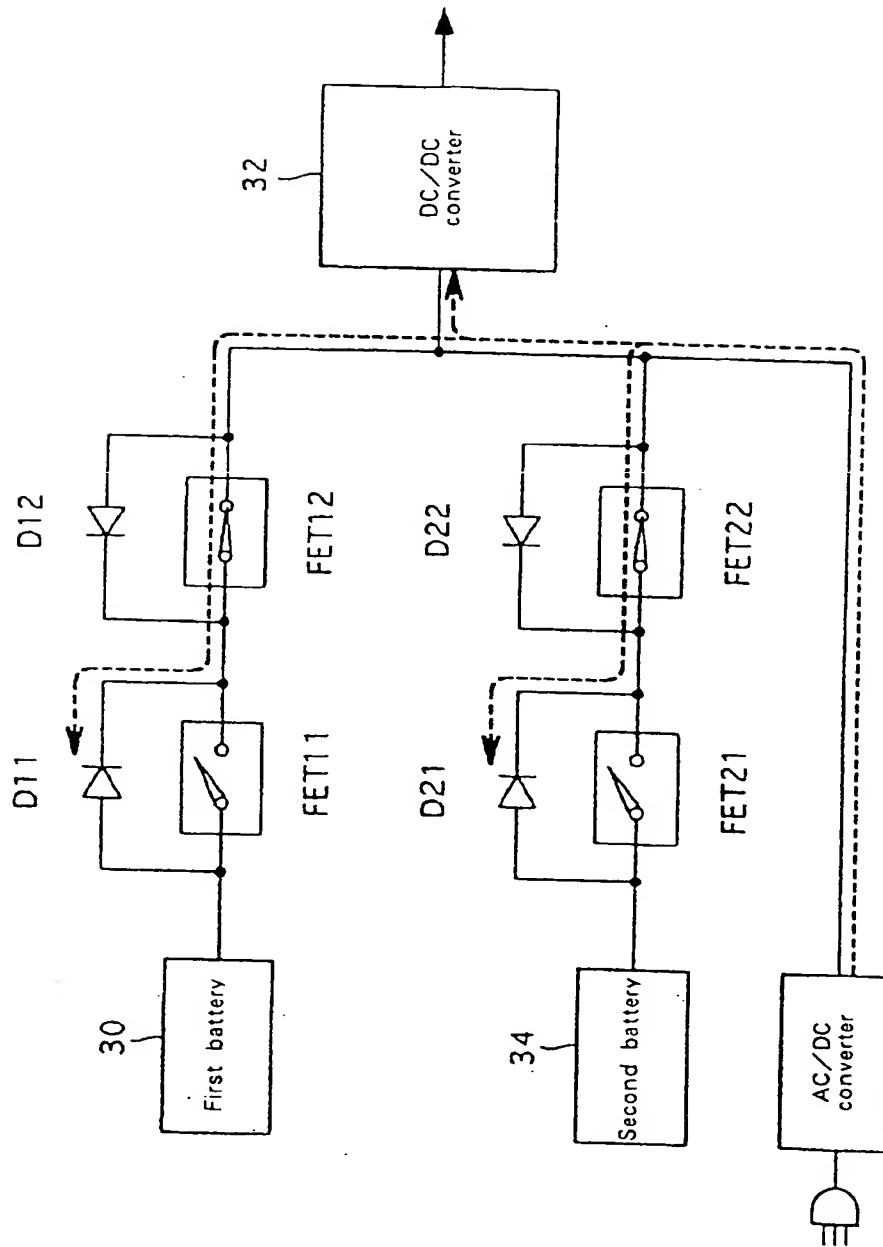


FIG. 19

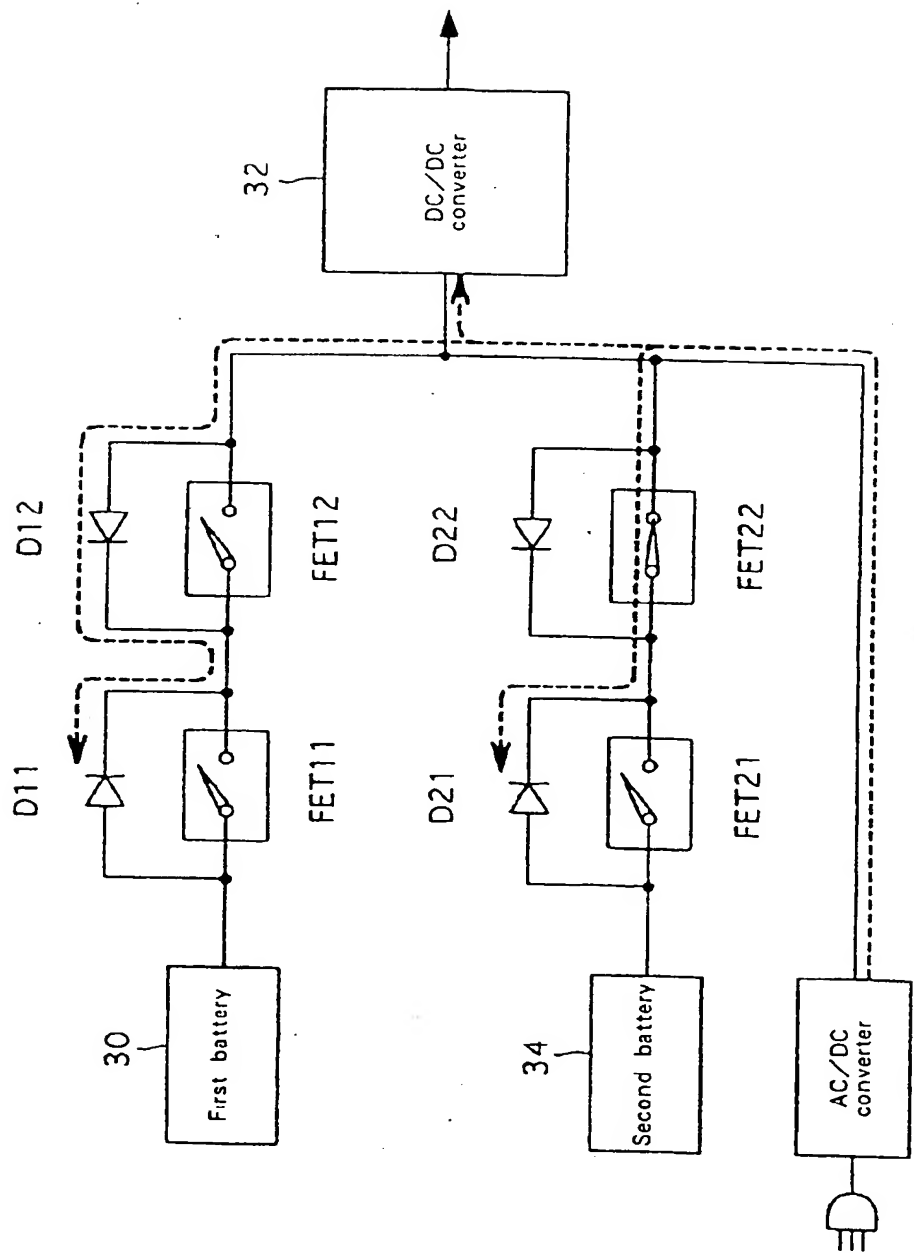


FIG. 20

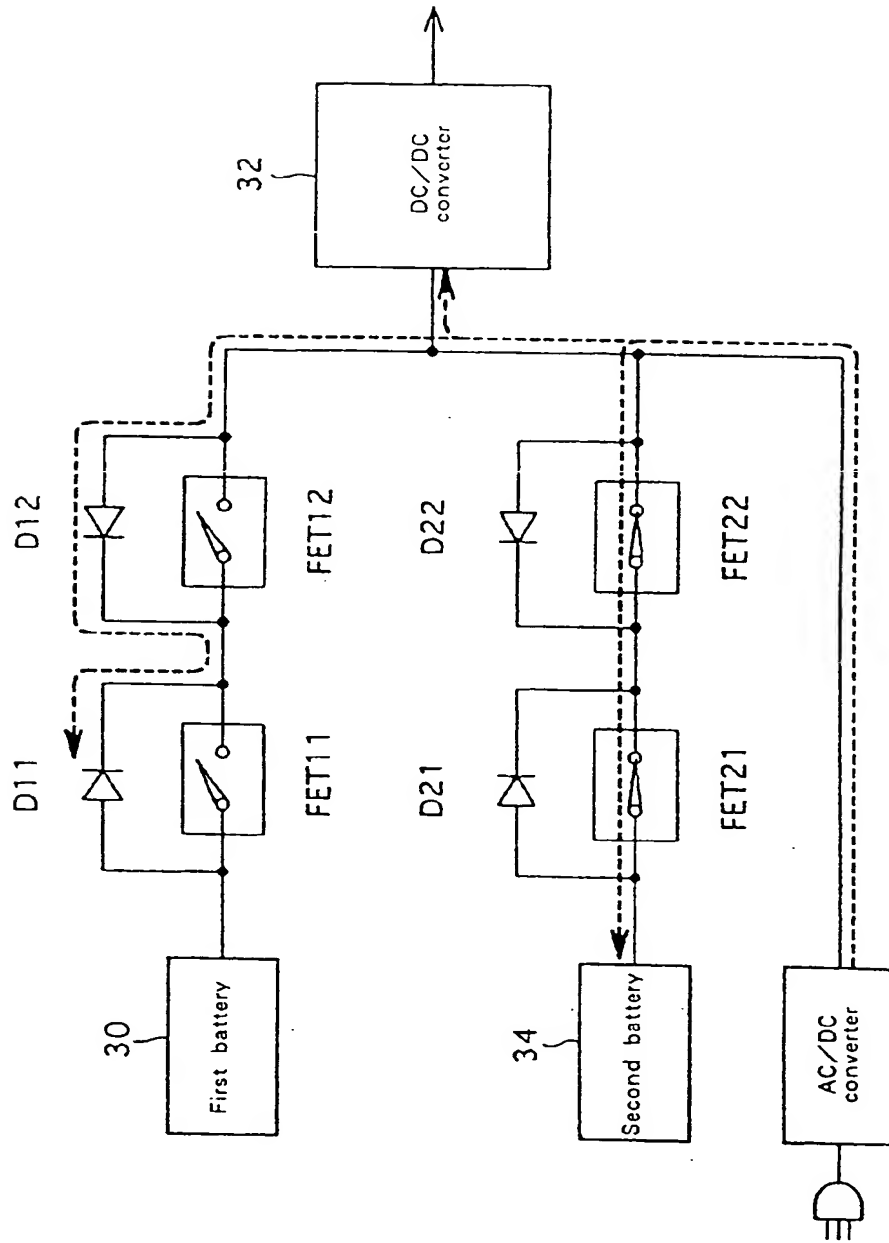


FIG. 21

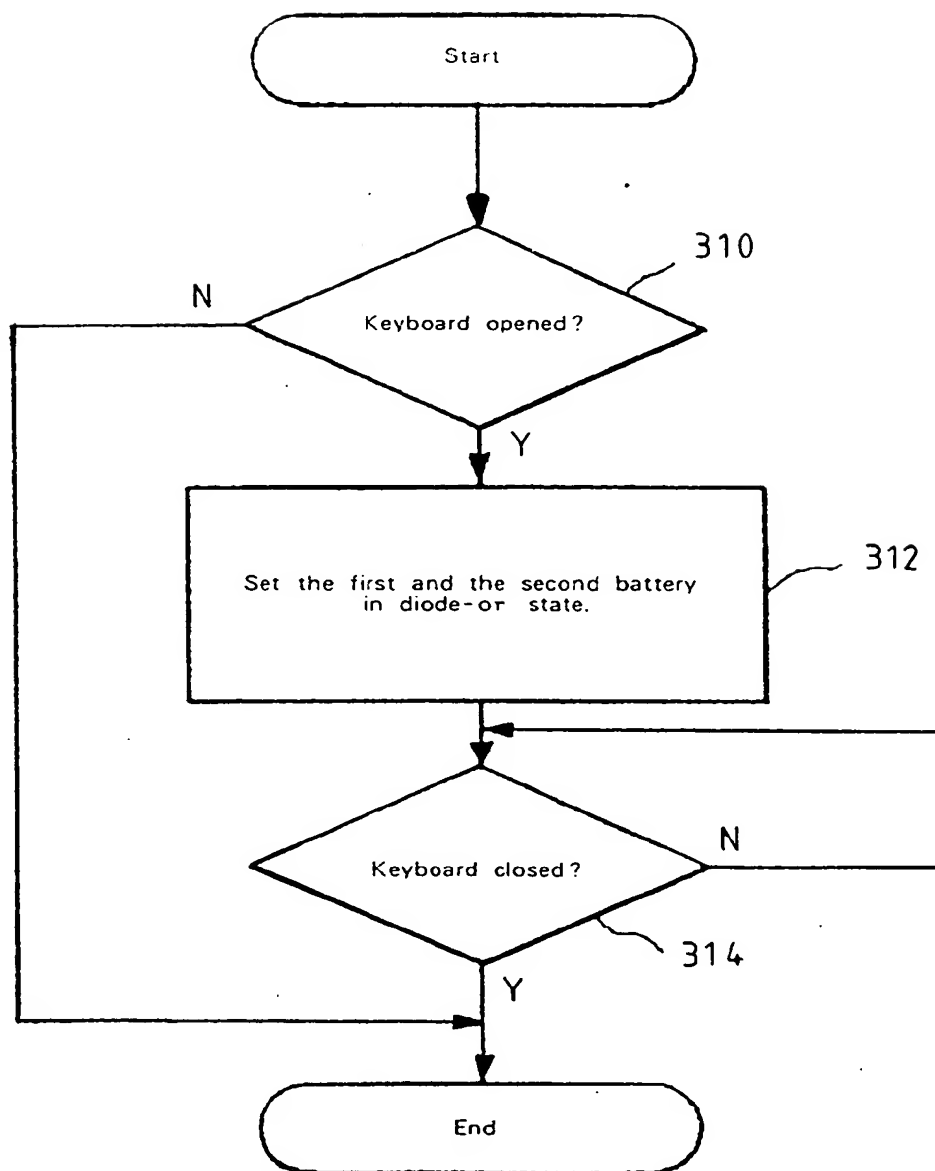


FIG. 22

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